This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

BRANNER
GEOLOGICAL LIBRARY

STANFORD UNIVERSITY LIBRARIES

J C Branner

37883

THE

GEOLOGICAL MAGAZINE:

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. CCCXXXI. TO CCCXLII.

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., F.Z.S., F.R.M.S.,

OF THE BRITISH MUSEUM OF NATURAL HISTORY;

VICE-PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY,

MEMBER OF THE LYCEUM OF NATURAL HISTORY, NEW YORK; AND OF THE AMERICAN PHILOSOPHICAL
SOCIETY, PHILADELPHIA; HONORARY MEMBER OF THE YORKSHIRE PHILOSOPHICAL
SOCIETY; OF THE GEOLOGISTS' ASSOCIATION, LONDON; OF THE GEOLOGICAL
SOCIETIES OF EDINBURGH, GLASGOW, HALIFAX, LIVERPOOL, AND NORWICH; CORRESPONDING MEMBER OF THE GEOLOGICAL SOCIETY
OF BELGIUM; OF THE IMPERIAL SOCIETY OF NATURAL
HISTORY OF MOSCOW; OF THE NATURAL HISTORY
SOCIETY OF MONTREAL; AND OF THE
MALACOLOGICAL SOCIETY
OF BELGIUM.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., F.C.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., PRES.G.S., F.L.S., F.C.S.

AND

GEORGE J. HINDE, PH.D., V.P.G.S., &c.

NEW SERIES. DECADE III. VOL. IX.
JANUARY—DECEMBER, 1892.

LONDON:
KEGAN PAUL, TRENCH, TRÜBNER & Co., LIMITED,
PATERNOSTER HOUSE, CHARING CROSS ROAD, W.C.
F. SAVY, 77, BOULEVART ST.-GERMAIN, PARIS.
1892.

St

HERTFORD:
PRINTED BY STEPHEN AUSTIN AND SONS.

210755

THE

GEOLOGICAL MAGAZINE.

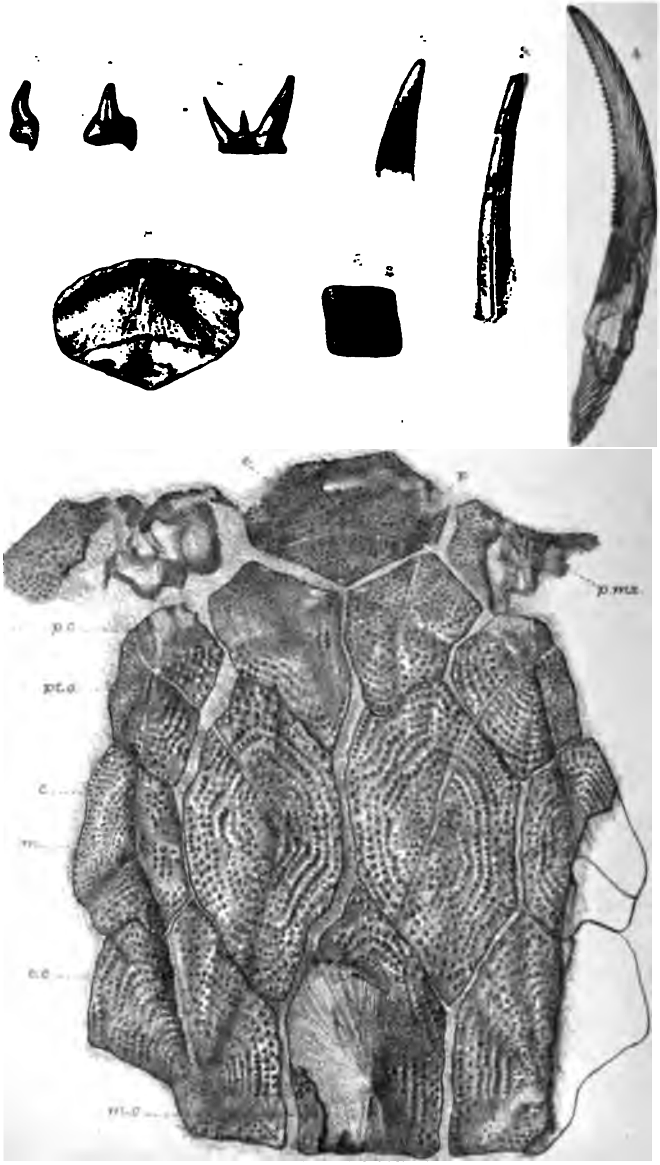
NEW SERIES.

DECADE III. VOL. IX.

JANUARY—DECEMBER 1892.

LIST OF WOODCUTS.

PAGE
1. Microscopic Sections of Micaceous Limestone from the St. Gothard Tunnel 16
2. Sections in the Cambrian rocks of Wales 23
3. Iguanodont tooth from the "Totternhoe Stone," near Hitchin. . . . 49
4. *Onychodus scoticus*, E. T. Newton, sp. nov. 51
5. William Smith's Monument at Churchill 96
6. Outline Map of the English Lake-District 98
7. Sections of Flexible Limestone 123
8. *Discinocaris Dusliana*, Novák, sp. nov. 148
9. *Clymenia Neapolitana*, Clarke. 174
10. Major John Plant, F.G.S. 286
11. Diagram to illustrate Mr. Davison's paper on British Earthquakes of 1891 301
12. Map to illustrate Mr. Hunt's paper on the Devonian Rocks of South Devon 344
13. Map of South Russia 387
14. Section at North Allington 439
15. Spine of *Phlyctænaspis acadica* 482
16. Jaw-plates of *Bothriolepis canadensis* 484
17. Section of Faulted Drift on Sea-cliff, Cumberland 490
18. *Ichthyosaurus*, showing dermal integument 517
19. Outline-restoration of *Sclerorhynclins atavus*, A. S. Woodward . . . 531



Woodward del.et lith. West Newman imp.

Lower Devonian Fishes of Canada.

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IX,

No. I.—JANUARY, 1892.

ORIGINAL ARTICLES.

1.—On the Lower Devonian Fish-Fauna of Campbellton, New Brunswick.

By Arthur Smith Woodward, F.L.S., F.G.S.

(PLATE I.)

THE Lower Devonian Fish-Fauna of Campbellton, New Brunswick, has already been described by Mr. Whiteaves,[1] of the Canadian Geological Survey, and Dr. Traquair,[2] of Edinburgh; and a few supplementary observations are published in the British Museum Catalogue of Fossil Fishes, Part II. (1891). Much, however, still remains to be learned concerning the skeletal anatomy of the genera and species already determined; and many types of early fishes will doubtless soon be discovered by future explorers of the formation and locality in question. A new series of specimens just received by the British Museum from Mr. R. F. Damon, of Weymouth, adds some small items of interest to our knowledge of the subject; and the following notes relate to the advance thus made. The fossils under discussion were collected last summer by Mr. Jex, and are all much crushed and flattened in the usual manner.

ELASMOBRANCHII.

Genus Protodus, nov.

A genus known only by detached teeth. Dental crown consisting of a single robust, solid, conical cusp, invested with gano-dentine; root large, undivided, laterally expanded, and antero-posteriorly compressed.

That the tooth thus defined is not the laniary of a Crossopterygian attached to its basal bone is proved by the examination of a microscopical section, which leaves little doubt as to its Elasmobranch relationships. *Protodus* is thus the earliest tooth referable to the Elasmobranchii hitherto determined, and is especially remarkable on account of the form of the root. There is much reason to believe that all the more primitive Elasmobranch teeth possess a horizontally expanded base (or root), while antero-posterior compression is the result of specialization. Such being the case, *Protodus* is a specialized form of a very simple type of tooth.

---

[1] J. F. Whiteaves, Canadian Naturalist, n.s. vol. x. (1881), pp. 93–100; also "Illustrations of the Fossil Fishes of the Devonian Rocks of Canada, Part II.," Trans. Roy. Soc. Canada, vol. vi. sect. iv. (1889), pp. 92–96, pl. ix. pl. x. figs. 2–4.

[2] R. H. Traquair, "Notes on the Devonian Fishes of Scaumenac Bay and Campbelltown in Canada," Geol. Mag. [3] Vol. VII. (1890), pp. 20–22; also "On *Phlyctænius*, a New Genus of Coccosteidæ," *ibid.* pp. 55–60, pl. iii.

1. *Protodus Jexi*, sp. nov. Pl. I. Figs. 1, 1*a*.

Crown of tooth attaining a height of about 0·005, and measuring 0·003 in width at the base; the apical half sharply bent inwards; coronal surface smooth, the lateral margins keeled, both faces convex, and the outer face with an unsymmetrically placed longitudinal ridge imparting to the tooth a twisted appearance. Root compact, stouter and much less deep than the crown.

The best-preserved specimen is shown of the natural size in Pl. I. Figs. 1, 1*a*, and there are four more imperfect examples in the collection. The specific name is suggested in honour of Mr. Jex, of Weymouth, to whose skill in collecting so many remarkable discoveries of Devonian and Carboniferous fishes, both British and Canadian, are due.

Genus Diplodus, Agassiz.

[Poiss. Foss. vol. iii. 1843, p. 204.]

Teeth of this form are now known to be common to several genera of primitive Elasmobranchs, already discovered in formations ranging from the Lower Carboniferous to the Upper Trias. A unique specimen in the new collection of Lower Devonian fish-remains from Campbellton now seems to show that the same type of tooth occurred in certain Elasmobranch Fishes even in the early portion of the Devonian period; and the discovery of parts of the skeleton of these ancient forms will be awaited with considerable interest.

2. *Diplodus problematicus*, sp. nov. Pl. I. Fig. 2.

The single tooth referred to appears to be destitute of the root and exhibits only the outer face of the crown. It is shown of three times the natural size in Pl. I. Fig. 2. The two principal cusps are well separated, unequal in size, and widely divergent; each being long and slender, somewhat tumid in the basal portion, and attenuated distally. The median cusp or denticle is subulate, long and slender. The gano-dentine is quite smooth.

Though several forms of "*Diplodus*" are known to occur in one and the same mouth of some Pleuracanth fishes, and the recognition of specific characters in detached teeth thus becomes impossible; it still seems advisable to adopt provisional names for isolated examples, and the Lower Devonian tooth described above may thus be known as *Diplodus problematicus*. More especially does this name appear to be appropriate, as the form of the root and the microscopical structure of the tooth yet remain to be determined.

Genus Gyracanthus, Agassiz.

[Poiss. Foss. vol. iii. 1837, p. 17.]

3. *Gyracanthus incurvus*, Traquair. Pl. I. Figs. 4, 5.

1890. R. H. Traquair, Geol. Mag. [3] Vol. VII. p. 21.

A small, much arcuated, and laterally compressed spine, attaining a length of about 0·065. Anterior border acute; posterior border with a single regular series of closely arranged, small stout denticles. Lateral ornamentation delicate, consisting of numerous sharp ridges, disposed with a very slight obliquity, which increases towards the base and towards the anterior border; the ridges coarsest and most widely spaced at the base and at the anterior border, sometimes smooth, sometimes in part crenulated.

Four examples of this interesting ichthyodorulite are contained in the new collection from Campbellton, and the finest specimen is shown of the natural size in Pl. I. Fig. 4. The fossil is imperfect in the basal half, though exhibiting all the principal characters of the species; and the sharp oblique line of demarcation between the inserted and exserted portions is conspicuous. Another specimen seems to show distinct abrasion of the apex (Pl. I. Fig. 5), such as is a well-known feature of the typical Carboniferous *Gyracanthus*; and a third fragment has been sliced transversely to obtain a microscopical section. The central cavity of the spine is thus proved to to have extended far towards the apex, and the tissue consists wholly of vaso-dentine.

Genus CLIMATIUS, Agassiz.

[Poiss. Foss. V. G. R. 1845, p. 119.]

4. *Climatius latispinosus*, Whiteaves, sp.

1881–89. *Ctenacanthus latispinosus*, J. F. Whiteaves, Canadian Nat. n.s. vol. x. p. 99, and Trans. Roy, Soc. Canada, vol. vi. sect. iv. p. 95, pl. x. fig. 3.
1889. A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. iv. p. 183.

Numerous isolated spines of this large species of Acanthodian fish are contained in the collection. It is especially interesting to observe that in addition to the ordinary fin-spines already known, there are also some extremely broad and short triangular spines precisely similar to the intermediate ventral spines of the typical British species of *Climatius*. These are marked with radiating, sparsely tuberculated ridges, and their base of insertion is very narrow.

Genus ACANTHODES, Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1833, p. 19.]

5. *Acanthodes semistriatus*, sp. nov. Pl. I. Fig. 3.

Body much elongated and slender. Fin-spines much laterally compressed, with a single deep and broad longitudinal groove dividing each lateral face into a narrow smooth anterior area and a somewhat wider, finely striated posterior area. Pelvic fins situated nearer to the anal than to the pectorals, and the anal slightly in advance of the dorsal. Pelvic fin-spine apparently almost as large as the anal, and the latter much smaller than the dorsal. Scales smooth, the surface faintly excavated or flat.

The above definition is based upon a single imperfect fish (No. P. 6545) about 0·15 in length, and having the dorsal fin-spine 0·02 in length. Two large detached spines, however, remarkably similar to those of the type specimen, may probably be regarded as indicating *that the species sometimes* attained to much larger dimensions; and one of these spines is shown of the natural size in Pl. I. Fig. 3.

A. semistriatus pertains to the primitive section of the genus (*Mesacanthus* of Traquair) already well known in the Lower Devonian, but attains to at least twice as large a size as any of its congeners hitherto discovered.

OSTRACODERMI.

Genus Cephalaspis, Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1835, p. 135.]

6. *Cephalaspis campbelltonensis*, Whiteaves. Pl. I. Fig. 6.

1881–89. J. F. Whiteaves, Canadian Nat. n.s. vol. x. p. 98, and Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 92, pl. x. fig. 2.
1890. R. H. Traquair, Geol. Mag. [3] Vol. VII. p. 21.
1890. *Cephalaspis Whiteavesi*, R. H. Traquair, *ibid.* p. 21.
1891. A. S. Woodward, Catal. Foss. Fishes B. M. pt. ii. p. 190, pl. ix. fig. 5.

This is one of the commonest fishes in the Campbellton shale, but the specimens are almost invariably so much crushed and broken that the characters of the species are difficult to determine. The latest definition, given in the British Museum "Catalogue," seems to be correct; and the examples of the head-shield in the new collection display only two features worthy of special note.

The most remarkable of these features—and one probably of much significance—is the conspicuous difference between the structure of the main part of the shield and that of the region termed the "post-orbital valley." Whereas in shields that have lost the superficial layer, the tesseræ of the middle layer are well shown in every part outside the "post-orbital valley," in this small area the tissue is observed to be thickened and dense, with a splintery fracture, and without any sutures or conspicuous vascular canals. This hardened plate, indeed, is so sharply separated from the surrounding shield, that it has the appearance of an entirely independent element; and the writer is inclined to believe that some other Cephalaspidian shields in the British Museum, from the English Old Red Sandstone, exhibit characters capable of a similar interpretation.

The tubercular nature of the superficial ornament of the shield is also noteworthy. One specimen shows well-separated rounded tubercles on the upper aspect of the cornua; and the inferior rim and rostrum of another specimen are marked with closely arranged, flattened, irregularly stellate tubercles, sometimes almost fused into a network.

Finally, the new collection is interesting as comprising a single specimen in which remains of the greater part of the squamation of the trunk are preserved. The scales are unfortunately so much crushed, broken, and displaced, that little of their arrangement can be determined; but their general appearance suggests that there were fewer deep and narrow scales than in the typical species of which the trunk is well known. Many of the scales are nearly equilateral (Pl. I. Fig. 6), and exhibit a very narrow overlapped border. The hinder border is not serrated, but the unabraded with a single regular series of closely arranged, small stout denticles. Lateral ornamentation delicate, consisting of numerous sharp ridges, disposed with a very slight obliquity, which increases towards the base and towards the anterior border; the ridges coarsest and most widely spaced at the base and at the anterior border, sometimes smooth, sometimes in part crenulated.

Four examples of this interesting ichthyodorulite are contained in the new collection from Campbellton, and the finest specimen is shown of the natural size in Pl. I. Fig. 4. The fossil is imperfect in the basal half, though exhibiting all the principal characters of the species; and the sharp oblique line of demarcation between the inserted and exserted portions is conspicuous. Another specimen seems to show distinct abrasion of the apex (Pl. I. Fig. 5), such as is a well-known feature of the typical Carboniferous *Gyracanthus*; and a third fragment has been sliced transversely to obtain a microscopical section. The central cavity of the spine is thus proved to to have extended far towards the apex, and the tissue consists wholly of vaso-dentine.

Genus CLIMATIUS, Agassiz.

[Poiss. Foss. V. G. R. 1845, p. 119.]

4. *Climatius latispinosus*, Whiteaves, sp.

1881–89. *Ctenacanthus latispinosus*, J. F. Whiteaves, Canadian Nat. n.s. vol. x. p. 99, and Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 95, pl. x. fig. 3.
1889. A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. iv. p. 183.

Numerous isolated spines of this large species of Acanthodian fish are contained in the collection. It is especially interesting to observe that in addition to the ordinary fin-spines already known, there are also some extremely broad and short triangular spines precisely similar to the intermediate ventral spines of the typical British species of *Climatius*. These are marked with radiating, sparsely tuberculated ridges, and their base of insertion is very narrow.

Genus ACANTHODES, Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1833, p. 19.]

5. *Acanthodes semistriatus*, sp. nov. Pl. I. Fig. 3.

Body much elongated and slender. Fin-spines much laterally compressed, with a single deep and broad longitudinal groove dividing each lateral face into a narrow smooth anterior area and a somewhat wider, finely striated posterior area. Pelvic fins situated nearer to the anal than to the pectorals, and the anal slightly in advance of the dorsal. Pelvic fin-spine apparently almost as large as the anal, and the latter much smaller than the dorsal. Scales smooth, the surface faintly excavated or flat.

The above definition is based upon a single imperfect fish (No. P. 6545) about 0·15 in length, and having the dorsal fin-spine 0·02 in length. Two large detached spines, however, remarkably similar to those of the type specimen, may probably be regarded as indicating that the species *sometimes* attained to much larger consideration show the small pineal plate ("posterior ethmoid" of Traquair) fused with the large ethmoid ("anterior ethmoid" of Traquair) in front, but separated by a distinct sutural line. The great pineal pit at the hinder angle of the "rostral" plate thus formed is well indicated in Pl. I. Fig. 8.

Several plates of the body cuirass are also contained in the latest collection from Campbellton. There are examples of the lateral and ventrolateral plates (Whiteaves, *loc. cit.* pl. ix. figs. 3, 4); and two groups of smaller, sparsely tuberculated plates cannot even be provisionally determined. Further discoveries must be awaited before any definite information concerning the disposition of the armature is obtainable.

EXPLANATION OF PLATE I.

Fish-remains from the Lower Devonian of Campbellton, New Brunswick.

FIG. 1. *Protodus Jexi*, sp. nov.; tooth, outer and lateral (1*a*) aspects.
„ 2. *Diplodus problematicus*, sp. nov.; tooth, outer aspect, three times nat. size.
„ 3. *Acanthodes semistriatus*, sp. nov.; fin-spine.
„ 4. *Gyracanthus incurvus*, Traq.; spine, lateral aspect.
„ 5. Ditto; abraded apex of spine, lateral aspect.
„ 6. *Cephalaspis campbelltonensis*, Whiteaves sp.; scale, external aspect, three times natural size.
„ 7. *Phlyctænaspis acadica*, Whiteaves sp.; head-shield, external aspect. *c.* central; *e.* ethmoid; *e.o.* external occipital; *m.* marginal; *m.o.* median occipital; *p.* pineal; *p.mx.* premaxilla; *p.o.* preorbital; *pt.o.* post-orbital.
„ 8. Ditto; ethmoidal (*e*) and pineal (*p*) plates, visceral aspect.

All the specimens are preserved in the Geological Department of the British Museum (Natural History), and, unless otherwise stated, the drawings are of the natural size.

II.—REMARKS ON PROF. BONNEY'S PAPER "ON THE CRYSTALLINE SCHISTS AND THEIR RELATION TO THE MESOZOIC ROCKS IN THE LEPONTINE ALPS."

By Dr. F. M. STAPFF.

I VENTURE to offer some remarks on the above-mentioned paper of Prof. Bonney, which appeared in the Quarterly Journal of the Geological Society for May, 1890 (vol. xlvi. pp. 187–240).[1] As the result of ten years' geological researches in the St. Gothard district, I have become familiar with most of the statements and arguments brought forward by Prof. Bonney; many of them, I am glad to see, agree with my own observations and views, already made known in official and other publications; others, however, I feel bound to dispute.

I.—*The black schists.*—Prof. Bonney's view that the "*black garnet schists*" of the St. Gothard (Nufenen to Lukmanien) are not identical with the *belemnitiferous black* "*spotted*" *schists* of the Nufenen (Bonney, *l.c.* pp. 214, 218, 220, 221) has been held by me since

---

[1] It will, we are sure, gratify our readers to learn that Dr. Stapff, the writer of the present article, was the eminent engineer of the St. Gothard tunnel. By accident Prof. Bonney has referred to him in the Quart. Journ. Geol. Soc. 1890, vol. xlvi. p. 196, as "the *late* Dr. Stapf" (for Stapf read Stapff). We are glad to be able to state that Dr. Stapff is alive and well.—EDIT. GEOL. MAG.

1875, and I am glad to find it supported by so high an authority. In a paper I read at the 58th annual meeting of the Schweizerische Naturforschende Gesellschaft, held at Andermatt, September, 1875 (Jahresbericht, 1874–5, pp. 127—156), is the following:—

"Worthy of attention is the frequent association (in the southern section of the Gothard tunnel, 700—800 m. from the mouth) of this calc-mica schist with dark, dense, often phyllitic mica schists which resemble some of the Nufenen 'Knotenschiefer' in having knobs of small garnets. But it should be kept in mind that two different kinds of spotted schists occur in the Nufenen pass. In one of them the knobs are garnets; in the other one cylinders and hail-like grains of a zeolithic[1] mineral, and the belemnites are exclusively found in this last-named variety" (*l.c.* p. 140). Further, the following will be found in the text to "Profil géologique du St. Gothard dans l'axe du grand tunnel établi pendant la construction (1873–1880) par F. M. Stapff, ingénieur-géologue de la Compagnie du St. Gothard" (Annexe spéciale aux rapports du Conseil fédéral Suisse sur la marche de l'entreprise du St. Gothard; Berne, 1881), "The *black schists* of the *Oberalp road* (north side of the Gothard) might be paralleled with certain *black garnet schists of the south side* (Nufenen schists in part.)—Footnote. The belemnites do not appear in the black garnet schists of the Nufenen pass, but in a kind of black schist which much more reminds one of those from Altkirche (likewise on the north side of the Gothard, not far from the Oberalp road). The cylinders in this rock are composed of a zeolitic mineral (comp. *von Fritsch*, p. 127) which probably accounts for the hydraulic qualities which calcined lime exhibits when mixed up with slightly burnt and ground belemnite-schist from the Nufenen. If this parallelization be correct, and the metamorphosed sedimentary rocks of the Ursern valley properly determined, then we may draw the conclusion that the series of the originally sedimentary rocks on the south side of the Gothard begins, at the bottom of the Ticino valley, with *Jurassic* deposits and includes *Carboniferous* at about

---

[1] I am well aware that these grains and cylinders in the Nufenen schists are usually considered to be *couseranite*; but the existing chemical analyses allow them to be equally as well regarded as f. i. *prehnite*, and this interpretation is not contradicted by Prof. Bonney's microscopic analysis, though the shape of the prisms does not agree with the usual habit and mode of occurrence of prehnite.

Comparative analyses:—

	Mineral in the Nufenen schists.		To be compared with	
SiO^2:	knobs 53·09	prisms 40·07	Prehnite 43·63	Couseranite 52·37
Al^2O^3:	19·45	22·05	24·87	24·02
Fe^2O^3:	5·93	5·66	(6·81—7·38 in some varieties)	—
CaO:	10·95	22·29	27·14	11·[illegible]5
MgO:	1·03	1·20	—	1·40
H^2O:	6·06	8·89	4·36	KaO,NaO 9·48
Loss	3·49	—	—	—
	100·00	100·16	100·00	99·12

I observed the hydraulic character of the Nufenen schists whilst searching for hydraulic lime in the neighbourhood of Airolo, and made some laboratory tests with them.

1833 m. inside the mountain, counted from the mouth of the tunnel" (*loc. cit.* French text, p. 56; German, p. 51, 52). Describing the glacial and alluvial gravels in the Ticino valley ("Geologische Beobachtungen im Tessinthal, während Tracirung und Baues der Gotthardbahn," Berlin, 1883), I have likewise pointed out the difference between the ordinary black garnet schists and the Nufenen 'spotty' schists: whilst the former are spread far down the valley, the Nufenen 'spotty' schists were not met with beyond five or six kil. below the pass (*loc. cit.* p. 83).

The fact is, that schists and slates which are coloured by graphite or other coaly material, sometimes phyllitic, sometimes calciferous, and often garnet-bearing, occur on the Gothard under various conditions, and in widely separated geological horizons. On his map of the Gothard district, *von Fritsch* indicated by the colouration of the Nufenen schist, a patch of *black garnet schist* in the upper part of the Unteralpthal. On examination I found it to be a slender intercalation in the micaceous gneiss of the Sorescia type, which, on the summary profile to my geological map of the Gothard railway, is designated by III., and which has been cut by the tunnel between 3000 and 4000 m. from the southern entrance. This occurrence of black garnet schist in the brown micaceous gneiss III. is not an isolated one. I have mapped a quite analogous instance in the upper Val Cadlimo, close by the Lago Scuro.

On a higher horizon, we meet with the *black schists* (without macroscopic garnets) of the Oberalp road, which were exposed in the tunnel between 3650 and 3800 m. N.; probably they are of *Carboniferous age* and equivalent to the *black garnet schists* on the south side, at 1466 and 1808–1833 m.[1]

Some seams of *black schist* were met with in the tunnel at 3263 and 3274 m. N., between the Altkirche schists and the above-mentioned Oberalp schists, which have not been traced at the surface; they probably correspond with the *black garnet schists* on the south side at 700–800 m. The bed-rocks are calcareous on *both sides* of the mountain; I consider them to be of *Triassic* age, as well as the bulk of the calc-mica schists on the opposite side of the Ticino river, which also inclose several belts of *black garnet schists*, one, for example, in the Stalvedro railway tunnel.

Finally we arrive at the highest horizon of *black schists,* viz., those of Altkirche on the north side, met with in the tunnel at 2582, 2637, 2766 m. N., which I consider to be of *Liassic* age and to correspond with the *Nufenen belemnite schists.* These have not been seen in the southern section of the tunnel, though it is possible that they may be represented there by some geological equivalent.

These *different black schists* do not completely agree in their petrographic characters, not even if comparison is made with those which presumptively belong to the same geological age, and at present their presumed horizons are rather guessed at than accurately determined. But the ***black schists*** which are easily recognized, and in which fossils may be expected to occur, will one day prove valuable criteria for geological classification, and I have therefore indicated them, wherever they occur, not only in the profile of the Gothard tunnel, but also in the "Geologische Uebersichtskarte der Gotthardbahnstrecke Kil. 38–149 (Erstfeld-Castione); 10 Blätter im Maasstab 1:25000; im Auftrag der Direction der Gotthardbahn, 1885." In the title and index-sheet of this map, three distinct designations are given for at least four different sorts of black schists; the colours referring to similar petrographic characters, the letters and numbers to geological position. In this way (which, however, cannot be fully explained without the help of a descriptive text to the map) I have endeavoured to bring the beds together in the order in which they might be expected to succeed each other, without prejudicing the *final* geological grouping, or making the map useless in case some of my views respecting the geological position of some of the beds should subsequently prove erroneous.

---

[1] These and other intercalations of special geological interest have been purposely very prominently marked on the profil géologique in order to attract attention to them. For exact measures and details refer to my record: "Geologische Tabellen und Durchschnitte, über den grossen Gotthardtunnel; Specialbeilage zu den Berichten des Schweizerischen Bundesrathes über den Gang der Gotthardbahnunternehmung, 1873–1882."

II. *The gray mica schists, calc-mica schists, disthene schists.*—I have divided the rocks of the Ticino valley from the mouth of the tunnel inwards to the micaceous gneiss of the Gothard, into the following four groups:

37—90 *m.*; characteristic rocks: *dolomites.*
90—1142 m.; ,, ,, : *gray garnet-mica schists.*
1142—1833 m.; ,, ,, : *green and black garnet-mica schists.*
1833—3178 m.; ,, ,, : *felspathic-mica schists and amphibolic rocks.*

Prof. Bonney's "Val Piora schists" belong to the second of these groups (that of the gray garnet schists) and his "Val Tremola schists" to the third and fourth groups (green, black felspathic mica schists and amphibolic rocks). On my geological map of the railway, this whole series is marked by the figures IV. and V. and the *sericite* schists of the Ursern valley are understood to be equivalent to the *gray mica schists* of the south side. (Text to profile, French, p. 47; German, p. 43.)

In the composition of the gray mica schists, two species of mica, at least, take part; of these the gray is the characteristic one. In the text to the profile (German, p. 45; French, p. 49) this is described as "not positively identical with *paragonite*, though containing soda, as shown by blow-pipe tests; potash-mica also occurring in the same schist. When fused to a yellowish white enamel, it becomes intumescent giving a yellow tint to the flame. It has a silky lustre and talcose appearance under the microscope; with a silver-white or grey colour, which often assumes a greenish hue. In the immediate neighbourhood of quartz-veins with copper pyrites, ironspar, cyanite, tourmaline, muscovite, calcspar, etc., this same soda-mica often turns apple-green like that of *pregrattite*; this green colour is of dubious origin (NiO, CuO, Cr^2O^3?), and seems to fade on long exposure to light. The blackish-tint and semi-metallic lustre in the black garnet schists and in many calc schists is due to graphite; not only is this the case in this group of the mica-schist series (700—800 m.), but also in the following (green schists at 1318, 1466, 1808, 1828 m., etc.) and in the black schists of the north side. Garnets are seldom absent, but in the schists close to the dolomites they are small, rare, and sometimes scarcely visible. The second constituent mica is brown magnesian; it is in part original, in part a pseudomorph, after hornblende.

Disthene, cyanite, staurolite (rarely, for example, at 632 and 753 m.) occur in certain beds throughout the gray mica schists, whilst they are but sporadic or microscopic rarities in the succeeding green amphibolic and felspathic mica schists. Real staurolite schists comparable with the typical beds of Alpe Sponda have not been met with in the tunnel (text to profile, French, p. 50; German, p. 46) and large radiant prisms of disthene are commonly connected with quartz veins (180, 190, 397 m.), which at the same time carry copper pyrites, pyrrhotine, ironspar and tourmaline (rare). The beds in which disthene and kindred minerals can be recognized at a glance, *e.g.* at 190, 397, 536, 606, 632, 732, 792, 808, 854, 868, 912, 1119 mètres from the mouth, are usually connected with the calc-mica schists and black garnet schists; but it would be premature to assert that certain geological horizons in the gray mica schists are characterized by the appearance of disthene, etc.

The complex of gray mica schists containing garnets, disthene staurolite (tourmaline), appears again *on the opposite side of the Ticino valley* (up in the mountains), whence it enters Val Chironico, with the renowned Sponda Alp; and it may be seen from the geological map of the railway, plates vi. vii., that even here these mica schists are underlaid by micaceous gneiss and overlaid by real calc-mica schists, with intercalations of black schists, quartzites, and (last but not least) by dolomites, rauchwacke, marble, etc., in repeated beds.

The so-called *calc-mica schists* of the Gothard tunnel (south side, text to profile, French, p. 50; German, p. 45) differ to some extent from the calc-mica schists on the opposite side of the Ticino valley; the calcspar being scarce and often absent in the rusty outcrops of the small seams; which are then hardly recognizable as continuations of the corresponding calcareous mica schists in the tunnel (pl. v. of the geological map along the railway line). The calcspar usually occurs together with quartz or felspar, in thin crumpled, broken and faulted lamellæ, which by the decomposition of pyrites or carbonate of iron are often rusty and carious. Some quartzitic beds of this mica schist series and some amphibolites (*hemithrènes*) also yield grains and lamellæ of calcspar, and it would be interesting if there were means of distinguishing the original constituent from the secondary calcspar, so as to be able to decide whether these intercalated seams are real or pseudo calc-mica schists. With regard to their designation in the profile of the tunnel, I refer to the remarks made above respecting the black garnet schists.

Certain seams of the sericitic schists of the Ursern valley (north side) are also calcareous (3255–85; 3560–70; 3650, 3666 m. N., German text to profile, p. 22; French, p. 24) and thus comparable with the described calc-mica schists of the south side. Macroscopic garnets, disthene, etc., are lacking on the north side, where *anhydrite,*[1] *gypsum*, and gunpowder-like *magnetic iron* are interesting accessory constituents of the calcareous sericite schists; and the presence of *rolled grains of quartz* prove them to be originally psammitic rocks.

It should, moreover, be kept in mind that sporadic intercalations of calcspar are by no means rare in the crystalline schists of the St. Gothard. They frequently occur in the green felspathic and amphibolitic schists of the south side; in the black schists of the Oberalp road on the north side; sometimes also in the micaceous gneiss of the Gothard massif. Intercalations of limestone always point to an original sedimentary formation of the surrounding schist. A direct proof of this is the existence of *rolled gravels* in the amphibolic mica schist at 396 m. S. (text to profile, French, p. 52; German, p. 48. Geolog. Durchsch., Südseite, Nos. 55, 56); of *rolled quartz grains* in the sericitic schist (text to profile, French, p. 25; German, p. 20. Geolog. Durchsch., Nordseite, No. 64, 68, 69, 72, 74, 76, p. 83), and of *psammitic quartz rock* (talc quartzite; verrucano?) between the beds of black schist at 3733, 70, 80, 94 m. N.

The calc-mica schist at the mouth of the Moësa, in the Ticino (pl. x. geol. map along railway), is in a greatly advanced condition of metamorphism, but though changed into calcareous gneiss with accessory disthene, garnets, actinolite, and titanite, and including beds of marble and cipoline, it must be considered as the equivalent of the calc-mica schists of Airolo (tunnel), and of the mica-schist with imbedded calcareous rocks of the Jorio pass (summary profile of the railway on title sheet of the map).

Continuing the parallelization of the schists on the south side of the St. Gothard with those on its north side, we have to place against the *green garnet-mica schists* with their intercalations of *black garnet schists, calc-mica schists,* and *quartzites,* the *black schists of the Oberalp road* with their belongings, and against the *felspathic mica schists* and *amphibolic rocks* of the Scipsius (IV. in the scheme on title plate of the map) the slaty gneiss of the north side for which I have proposed the name *Ursern-gneiss* (see sub-section V.).

An analogous rock, with striking intercalations of *hälleflinta,* is passed by the railway line near Gurtnellen on the northern flank of the granitic gneiss belonging to the Finsteraarhorn massif (Geol. Map, pl. iii. and title sheet), and southwards from Airolo a corresponding gneiss underlies the gray mica schists below Passo Sassella (pl. vi.), and between Monte Piottino (Daziogrande) and *Monte Olina* (Val Chironico). But amphibolic rocks, which abound near Airolo, are rare or altogether absent in the other localities (Ursern valley, Gurtnellen, Val Chironico).

III. *Dolomite, rauchwacke, marble, cipoline, and subordinate rocks.* —The detailed section between 37 and 90 mètres from the southern entrance of the tunnel, shown on a scale of 1:200 on plate i. of the

---

[1] Zeitsch. d. deutsch. geol. Gesellsch, 1879, p. 407.

Geol. Durchschnitte, Südseite, is highly instructive for the interpretation of the rather irregular or lenticular masses of rauchwacke which figure on the geological maps of the country. The same rock which, in the ragged cliffs N.E. and S.W. of the tunnel, appears almost homogeneous (though greatly decayed), is, in the tunnel, unrolled in a long series of alternating concordant strata of *rauchwacke, saccharoidal dolomite, marble, breccia, 'ash,' quartzite,* and *mica schist,* this last named forming not only some well-defined beds at the end of the series, but also thin separating sheets between the different calcareous layers, and patches in their mass. I am not convinced that these fragments are, in all cases, the detritus of pre-existing mica schist inclosed in the lime rock; sometimes the white, gray, or greenish coatings of talcose mica appear to have been formed contemporaneously with the calcareous material or even subsequently; in other instances they are certainly torn and crushed fragments of the intercalated mica schist which have been squeezed into the dolomite by mechanical forces. Prof. Bonney lays stress upon the occurrence in the dolomites, etc., of fragments of mica schist, which indicate their psammitic nature. With the reservation just mentioned, I share this view, which I have already published in the "Geol. Durchschnitte und Tabellen, Südseite," specially with reference to No. 10 ("dolomitic ash," a dirty greenish medley of dolomite, talc, etc.) and to No. 14 ("breccia" at 78·5 m., which is thus described, "Yellowish, ashy, cavernous rauchwacke, inclosing sharp-edged fragments of talcose mica schist and of saccharoidal dolomite, with white or rusty saccharoidal or sandy dolomite in the cavities. This bed, so far as it is not a vein, *proves that the dolomitic strata are younger than the mica schist on their hanging wall*"). Very similar remarks are made in the text to the Geological profile (German, p. 44; French, p. 48, and in "Verhandl. der Schweiz. Naturf. Gesellsch." 1874–75, p. 139): "the occurrence of this mica-dolomite breccia seems to prove that the dolomites are younger than the surrounding mica schists."

Dolomitic material is predominant in the chequered line of thin strata in this section of the tunnel, which have together been subjected in common to contortion, faulting and squeezing, so that it is difficult to understand why the same mechanical forces should not have exercised similar metamorphic effects on every individual bed of the whole series, which they are believed to have exercised on *some* of them; why, for example, mechanical "marmorization" has taken place in No. 17 at 82·3—83 m.; but not in the preceding bed of white loose saccharoidal dolomite, nor in the following one of white and red dolomitic bands which alternate with strings of quartz and mica-schist? How are we to explain the alternation of beds of rauchwacke with saccharoidal limestone if the transformation of one of these substances into the other were due to pressure which has acted through the whole complex? Leaving on one side the formation of breccias, it does not seem probable that petrographic metamorphosis by mechanical forces has played an important rôle in our case; I am inclined to consider that the chemical or physical constitution of the different beds was originally dissimilar, so that the course and the results of any metamorphic action would necessarily have varied in different parts of the whole complex. Further, it is not necessary to assume that any *chemical* metamorphosis must have embraced an entire complex of calcareous or dolomitic strata; it might equally as well have been restricted to certain regions, (marked off by stratification, fissure, or other lines) thus producing heterogeneous mass-shaped intercalated deposits, such as for instance *gypsum* and *anhydrite* imbedded in rauchwacke. As a matter of course, these irregular intercalations are not then of marked value as geological horizons. At the Airolo mouth of the tunnel, *gypsum* or *anhydrite* only appeared as accessories in the quartzite beds, No. 20 and 22, belonging to the dolomitic series, and in fissures in the adjoining rocks. In the calcareous rocks of the Ursern Valley, the occurrence of gypsum was restricted to lumps of alabaster imbedded in the clayey southern wall-rock.

Having regard to the petrographic variety in rocks belonging to one and the same calcareous series, it seems hazardous to ascribe, *à priori*, a definite geological age to such rocks when they are met with isolated. For this reason I have indicated on the geological map of the railway line, by a single colour, all limestones ranging between the Jurassic and Archæan, noting by index letters their special petrographic characters (dolomite=D.; rauchwacke=R.; marble=M.; cipoline=C.; calc-schist=Cas.), and leaving the question of their exact geological range to future exploration. I have paralleled the limestone series of the Ursern valley, which is considered to be *Jurassic*, with the dolomitic series of the south side, in spite of considerable petrographic differences—rauchwacke and saccharoidal dolomites are, for instance, wanting in the tunnel below the Ursern valley, whilst cipoline predominates there, though absent on the south side, etc. The appearance of quartzitic beds in the foot-wall of the Jurassic (Liassic) rocks affords a means of identifying them on both sides of the St. Gothard. It has already been remarked in "Verhandl. der Schweizer Naturfor. Gesellsch." 1874–75, p. 139, and in the text to the "Geol. Profile" (French, p. 47; German, p. 43) that beds of quartzite (resp. sandstone) are regularly associated with the limestone series north and south; they occur, for instance, at the Nufenen pass (à la Cruina), in the tunnel, near Lago Ritom, near Prato, and, on the other side, on the Längisgrat, Furka, near Realp, and Altkirche.

The description given by Prof. Bonney on p. 210 of his paper of a section along a ravine in Val Canaria agrees in its principal features with my own surveys in the same ravine and the adjacent areas, which have been used for the construction of plate v. of the geological map of the railway; and on principle I cannot object to this author's explanation of repeated identical beds (rauchwacke, in this case) by faults instead of by folding, though I have based the construction of this part of the map on the supposition of folds. The construction of ideal folds on ideal sections means for me nothing but a way of indicating the *supposed identity of* certain beds, of which only the outcrops are known, and nothing more. From the same point of view I also constructed (on the profile of the line of the tunnel) two troughs and an intervening saddle in the Ursern valley, remarking (French text, p. 28; German, p. 26), "The saddles and troughs drawn indicate no more than *une manière de représenter* the course of the beds in the Ursern valley." The same remarks are applicable to the general section on plate vi. of the geological map, which represents an ideal connexion of repeated seams of dolomite, calc-schists, and black and gray mica schists, between Val Piora (Lago Cadagno) and Campolungo. I wish to say, that I am not now satisfied with that profile, as it was not necessary to compress the three or four beds between the Ticino valley and Campolungo in a complicated system of folds, since they can quite as well be representatives of different horizons of a couple of beds repeated by faulting.

It must be admitted that the probability of faulting is, *à priori*, greater than that of folding; this agrees with the mechanical conditions of contraction as explained by the Rev. O. Fisher in his "Physics of the Earth's Crust," and a most demonstrative example of this same view is shown in that part of the profile of the Gothard tunnel which represents the central part of the massif. The upheaval of the mountain, the swelling, uplifting and overthrow of the strata, are not so much due to wave-like folding of the crust, as to its crushing and to the shoving and squeezing of the flakes over and through one another.

IV. *Organic remains in the Calcareous beds of the St. Gothard.*—Though I have not succeeded in finding *crinoids* at every spot in the Ursern valley indicated on the geological map of *von Fritsch*, there is no doubt of the existence of imperfect fragments of these organisms in those and other places in the calcareous series of the valley (see pl. iii. of the geological map of the railway line). Cylindrical or elliptical sections of stems of crinoids or spines of echinoderms, have been observed also in the tunnel; for example, in the gray cipoline, No. 43, at 2593 m., and in the black schist, No. 46, at 2637 m., and in this latter undetermined *fucoids* were also present. In addition to these, microscopic globules of coaly matter and peculiar rod-like pyritic bodies, which in section resemble some forms of *foraminifera*, have been noticed (black schist, No. 42, at 2582 m.). Some laminæ of calcspar intersecting the crystalline limestones and cipoline, were not infrequently covered with a network of graphite (or other coaly material) so as to resemble organic forms, but they are not organic, and have never been represented as such by me (Geol. Durchsch. u. Tabellen, Nordseite, p. 54–59; text to geol. profile, French, p. 23, 24; German, p. 21, 22).

Only after a thorough examination of 26 slides taken from different beds of the calcareous series between 2582 m. and 2783 m. N. did I discover in two of them (No. 43 at 2593 m. and No. 45 at 2682 m.) traces of microscopic organic fragments,[1] which I have referred to in the "Zeitsch. d. deutsch. geol. Gesell." 1878, p. 138, as follows: "Only in Nos. 43 and 45 have those puzzling microscopic structures been noticed, of which I sent a drawing to Prof. Desor, 26th Feb. 1877, and to which I drew the attention of Prof. Zirkel by letter of 29th Oct. 1877. In the text to the geological profile (German, p. 22; French, p. 24) they are described as blackish indistinct points (pores) arranged in rows, so as to form four-rayed stars by their intersection at right angles to each other. Professor Gümbel, who examined my slides, declared them to be unequivocally structures of crinoids, and this accords with the occurrence of circular or elliptic sections of crinoid stems in the cipolines, both inside and outside the tunnel (Ruestli; heap E. from Altkirche). The woolly threads of graphite in No. 45 are partly grouped in polymorphous net-works, one of which I have copied in Zeitsch. d. deutsch. geol. Gesellsch. vol. xxx. 1878, p. 138. No palæontologist who has seen this slide has doubted the organic nature of the form contained in it; but the interpretations of its character have varied between corals, sponges, and bryozoa—Prof. J. Hall inclines to this latter view of their origin.

---

[1] Faint traces of structures, resembling those on No. 43, have also been lately noticed in a section of No. 47.

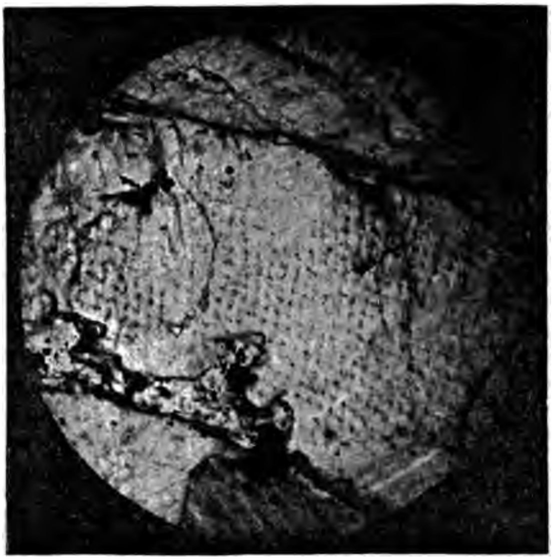
I believed the question of the organic character of the fragments in this highly crystalline micaceous limestone to have been settled; but finding that Prof. Bonney (*loc. cit.* p. 198, footnote) declared them anew to be *pseudo*-organic, I submitted the slides to Professor Möbius, Director of the Royal Museum at Berlin, so well known for his investigations on the structure of Eozoon, and he has given me permission to state that "*these forms in his opinion are of organic nature*, so far as can be judged from a hasty examination of only *two* slides, without comparing them with analogous structures." I have lately had taken microscopic photographs of the structures in the slides referred to, Nos. 43, 45, and the accompanying figures have been reproduced from them by autotypic process (see p. 16).

With regard to No. 45, I may remark that the light gray cross lines of the net-work seem in part to follow the cleavage faces through the calcspar, and would thus agree with Prof. Bonney's description of crinoidal microstructure in preparations from Scopi (*loc. cit.* p. 234–35). If No. 45 should beget any scruples as to its real nature, they would not affect No. 43, in which the black points and blisters are arranged in slightly curved lines, which intersect one another at angles of about 80° and 100°.

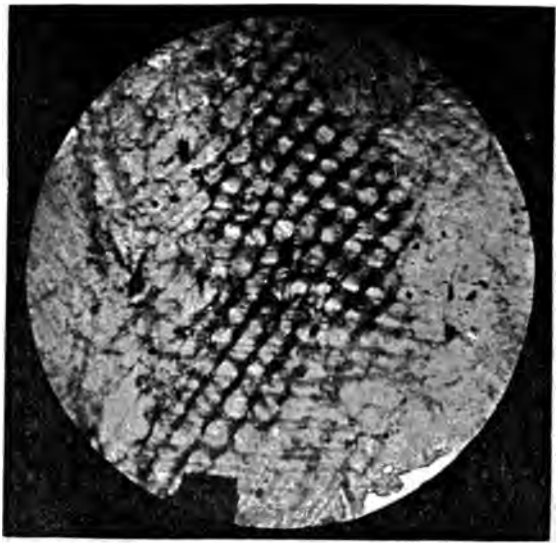
Though these microscopic traces of organisms in the Altkirche cipolines indicate the existence of crinoids, which were already known macroscopically and are without special value for the fixation of geological horizons, yet they are of great general interest as showing how the structure of fragmentary Jurassic fossils can be preserved in highly metamorphic micaceous limestone. It is now fourteen years since they were first noticed.

V. *Classification of the crystalline schists in the St. Gothard (and their relation to the Mesozoic rocks).*—The first arrangement of the beds passed through in the St. Gothard tunnel, which I sketched in the "Neues Jahrbuch für Mineralogie, etc.," 1878, has since re-

From Bed No. 43.



From Bed No. 45.



Microscopic Sections of Micaceous Limestone from the St. Gothard Tunnel.

EXPLANATION OF AUTOTYPE FIGURES ON PAGE 16.

Microscopic sections of micaceous limestone from the St. Gothard tunnel, showing traces of organic structures. Reproduced by Autotypic process. Enlarged to the scale of 180 diameters. The upper one is from Bed No. 43; the lower from Bed No. 45.[1]

mained the groundwork for the subsequent classifications published in the geological profile of the tunnel (1880), and in the title sheet of the geological map along the railway line (1885). The summary profile between the Lake of the four Cantons and that of Lugano, as there delineated on the scale of 1 :250,000, affords an insight into the structure of the Lepontine Alps which differs materially from others drawn up before the construction of the tunnel. Space would not permit me to give detailed references to this profile, and I shall therefore restrict myself to a sketch of the classification of the crystalline schists for which I wish to maintain my priority.

1. The *micaceous gneiss* with predominant magnesian-mica, which in the central part of the Gothard massif occupies the Guspis valley between Greno di Prosa (dividing ridge of the St. Gothard) and Alpetligrat, and extends in the tunnel for a distance of 2270 mètres, from 5450 m. S. to 7200 m. N., is the oldest or deepest of the crystalline schists of the St. Gothard, and as such is marked by *I*; *Guspis glimmergneiss*. One peculiarity of the same beds is the occurrence of black *tourmaline* together with garnets. Gneissic, micaceous, amphibolic, and quartzitic varieties, exist in it, as well as in the succeeding groups, and they have been carefully set out in the Geol. Durchsch. (1:200), and summarily in the profile of the tunnel, not only for engineering purposes, but also to serve as marks for the identification of crystalline strata on either side of the mountain.

The presence of *rolled* quartz grains (*sand*) in some beds of the Guspis micaceous gneiss, which have been duly noted in the Geol. Durchsch. (for instance No. 130 N. at 7262 m. p. 178, 9), and in the text to the geol. profile (German, pp. 28, 31, 36; French, pp. 31, 34, 39), proves beyond doubt the original sedimentary character of this gneiss, and this view is corroborated by the occurrence of occasional small bands of limestone (at 6100—6110, 7352 N.), frequently containing microscopic globules of graphite or other coaly material.[2] As a consequence, all the succeeding crystalline schists of the St. Gothard must also be considered to be metamorphosed sediments, so far as they cannot be shown to be of plutonic origin.

2. The *Sellagneiss*, southwards of the micaceous Guspis-gneiss and the Gamsboden-gneiss (a term introduced by *v. Fritsch*) northwards of it, occupy the second horizon of the crystalline schists, which is marked by *II*. I consider them equivalent to the Ticino gneiss south of the St. Gothard, which is crossed by the railway line between Daziogrande and Claro, and noted on pls. vi.—x. of the map

---

[1] As already mentioned by Prof. Bonney (*loc. cit.* p. 198) hand-specimens of these St. Gothard rocks are preserved in the Mineralogical Collection of the British Museum (Natural History), and sections, taken from the one marked No. 43, show precisely similar structures to those in the accompanying figure.—EDIT. GEOL. MAG.

[2] There is no question here about graphitic mirrors on fissures.

as Piottino[1] and Tessiner gneiss; and also equivalent to the gneiss in the neighbourhood of Erstfeld, north of St. Gothard (pl. i. of map). In the tunnel this gneiss with its varieties and occasional intercalations of micaceous and amphibolic rocks, occupy about 1000 mètres (4000—5000) on the south side, and 1400 m. (6000—7400) on the north side, but it should be observed that frequent repetitions and transitions of the terminal beds tend to make these limits rather elastic. The *Sella gneiss II.* is a highly crystalline felspathic rock, containing both potash- and magnesian-mica, and it has a veiny, uneven or lamellar, glandular structure.

3. The Sella gneiss is succeeded by the *micaceous gneiss III.*, named after the *Alpe Sorescia* on the south side, and after the *Gurschen Alp* on the northern side. It occupies in the tunnel 800 m. (3200–4000) on the south, and 1700 m. (4300–6000) on the north side. The predominant mica is brown or grey magnesian; that of the north side often assumes a green colour, and from this and from the occurrence of sericite it passes over into Ursern gneiss, whilst accessory garnets and hornblende in its boundary beds on the south side indicate a relation to the felspathic mica schist of the Scipsius. Moreover the rocks of this series have more frequently the character of mica schist than of gneiss.

The gneissic series *III.* is better characterized from a geological than from a petrographic standpoint. The peridotic and pyroxenic *serpentines* of the St. Gothard make their appearance in it, as also certain of the *black garnet schists* and some insignificant *ore deposits.* The *serpentines* which crop out along the Ursern valley, between the Unteralpthal, Gige, Hospenthal, and Zumdorf (pls. iii. and iv. of geol. map) were passed in the tunnel between 4870 and 5310 m. N.; and an analogous series of lenses of serpentine has been followed on the south side, in the same micaceous gneiss, on both slopes of the Val Tremola, near Seara Orell and Fieudo (pl. v. of geol. map), though not met with in the tunnel. Beyond the northern slope of the St. Gothard on the other side of the granitic Finsteraarhorn gneiss, *diallagic* (?) *rock* appears near Gurtnellen and down on the railway line near Meitschlingen in the same series III. (or IV.?). Finally, we find *serpentine* south of the Gothard in the neighbourhood of Bellinzona, at Castanetta, E. of the railway, and at Sementina W. of it—in both cases in micaceous gneiss belonging to III., which also is the prevailing rock of Mount Ceneri and in the Agno valley downwards to Gravesano and Manno, where it meets the Palæozoic rocks. (Profile on title-sheet of map.) The *black garnet schists* of the Unteralpthal and Val Cadlimo (Lagoscuro), which are imbedded in the micaceous gneiss III. have been mentioned under § I. Insignificant amounts of *zincblende*, *galena*, and *pyrites* have been found in the same gneiss, not only at the surface (mining trials in Val Cadlimo), but also in the tunnel at 3250–70, 3376, 3955 m. S., and at 4410 m. N. The zincblende formerly found near Hospenthal ("im Saum") and, together with mispickel, in the Tiefthal near Meitschlingen, on the north side of the Gothard, may also appertain to the same micaceous gneiss, as also that near St. Nazaro on the Lago Maggiore, where some small adits have been commenced in former times.

---

[1] "Piottino gneiss" means the uppermost beds which on Mount Piottino (Daziogrande) dip under the mica schist formation. Tessiner gneiss is an old term of Studer's, which refers to the nearly horizontal strata of gneiss along the Ticino, Near the railway station Claro they abruptly assume a sharp southward dip, and are then overlaid by a newer gneiss formation (See pls. ix. and x. of the map and Explanation of the same in Zeits. d. deutsch. geol. Gesells. 1884, vol. xxxvi., also Neues Jahrb. f. Mineral., 1882, vol. i. p. 72, where also the relation between the parallel structure and the stratification of the Piottino gneiss is treated of.

4. The fourth group of crystalline schists, comprising transition rocks between the gneiss-formation and the mica-schist formation, has already been mentioned in connexion with the last named (§ *II.*). The *Ursern gneiss* of the north side, and the *felspathic mica schists of the Scipsius* (south side) were passed in the tunnel between 2000—4300 m. N. and 1850—3200 m. S. respectively; the former enveloping the troughs of the Altkirche limestones and of the sericitic schists with the black schists of the Oberalp road. The appearance of slaty gneiss or felspathic mica schist northward and southward from the St. Gothard at Gurtnellen (probably also near Amsteg), in the Ticino valley south and west from Faido, between the Moësa and Bellinzona, at the foot of Mount Ceneri is recorded on plates ii. vi. viii. x. and on the summary profile of the geological map. Whilst the Ursern gneiss north of the Altkirche limestones is a genuine slaty felspar-gneiss, it has, south thereof, more relation with mica schist. Sericitic mica (besides the magnesian) and intercalations of quartzitic and gray-green micaceous beds indicate an analogy between these rocks on both sides of the limestones; but I should not be opposed to a separation of the same, if the deciphering of the geological structure of the Ursern valley would thereby be promoted. The felspathic mica schist of the Scipsius (south side) differs from the Ursern gneiss in containing abundantly beds of amphibolite; on the other hand, green micaceous and calcareous strata *are common* to the Scipsius schists and to the micaceous Ursern gneiss near its boundary with the Gothard massif.

In the summary profile I have made an attempt to parallel these groups of crystalline schists with the previous classifications of *Favre*, *von Hauer*, and *Gastaldi*, without being convinced that such a parallelization is practicable in detail; and a further attempt to fit these different crystalline schists into the frame of the American classification of the Archæan, I now recognize to be a mistake, since the Gothard rocks, from I. upwards, are decidedly *younger* than Archæan.

5. The rocks belonging to the fifth series, viz. gray and green mica schists, with or without garnets and disthene, sericite schists, black schists, calc schists, dolomites, cipoline, marble, rauchwacke, have been characterized in § I.–III., where it is pointed out that they extend from the Carboniferous to the Jurassic age. They occupy the trough of the Ticino on the south side, and on the north side that of the Ursern (pls. v.–vii. and iii.–iv. of the map; summary profile on title sheet); but they are represented also north of the Gothard,

between Gurtnellen and Amsteg (pl. ii.), and south of it in the Jorio pass, E. of the railway line; and the calcareous gneiss near Castione, with imbedded seams of marble (pl. x.), probably belongs here, though it is in a more advanced state of metamorphism.

O. The Ursern gneiss IV. is broken through by the *granitic gneiss* belonging to the *Finsteraarhorn massif*, over which the railway line runs from Göschenen to Gurtnellen (pls. ii. iii.). It differs from the gneiss of the St. Gothard and Ticino valley, not only by its compact structure, and the peculiar habitus of the quartz and felspars, but also by the predominant iron-magnesian-mica on the side of pellicular potash mica. I have marked it on the summary profile by O^e, thus indicating that it belongs to a series distinct from I.–IV. It is not eruptive or plutonic in the ordinary sense of the words, but it belongs rather to an horizon deeper than the lowest (I.) opened in the tunnel, and if thrust up in a solid state, it must consequently have been *after* the Gothard series, either in immediate connexion with the general disruption of the mountain or during subsequent paroxysms. Granulitic contact rock limits the granitic gneiss on its northern and southern boundaries (pls. ii.–iii.).

Eruptive rocks?—In connexion with the upthrusted but not eruptive granitic gneiss of the Finsteraarhorn massif, we have finally to consider two rocks of the St. Gothard which *seem* to be *intrusive*, viz., the *serpentines* and the *granite*. The peridotic *serpentines* already mentioned as embedded in the micaceous gneiss III. have been described petrographically in the Geol. Durchs. u. Tabellen, Nordseite, p. 114–123, and in the text to the geol. profile, German, p. 34; French, p. 38. With regard to their mode of occurrence some diagrams are given in "Materialen für das Gotthard profil; Verhandl. der Schweiz. Naturf. Gesellsch., 1878." In spite of the seeming discordance between the serpentine and the surrounding micaceous gneiss, which is very plainly seen in the figures of the treatises quoted above, I believe that the serpentine originally formed lenticular beds in the sedimentary series of crystalline schists, which in the process of general destruction have been severed in pieces and together with the wall-rock thrust along on the fissures. Wherever such a faulted fissure forms the local boundary between serpentine and micaceous gneiss, the former appears to penetrate the latter.

Granite.—A belt of granite extends eastwards from the Pizzo Rotondo on the north side of the Ticino valley, and disappears, after passing the Val Tremola, without reaching the line of the tunnel (pl. V.). It is a typical granite which does not belong to the St. Gothard series of crystalline schists; it has a compact granitic structure, and is distinguished by the light rose colour of its quartz. On the Alpe Fieudo (below the Fibbia), in Val Tremola, and near the Sella bridge (below the hospice), direct contacts between this granite and the micaceous gneiss (III.) show its intrusive character (sketch on pl. V. of geol. map. along the railway line), but stepping over the granite from its point of contact south of the Sella bridge, towards the Hospice, one observes a gradual transition into the so-called *Gothard granite* (Fibbia gneiss), or what I have designated as Sella gneiss (II.). Here the relation between the granite and gneiss becomes rather puzzling; I have shown its details in a profile (1:10,000) on pl. V. of the map, and described them in a paper ("Ueber das Verhältniss des Granits zum Gneiss am Gottbard") read at the 55th meeting of Deutsche Naturforscher u. Aerzte, held at Eisenach, 1882.

WEISSENSEE, BERLIN, 7 *Oct.*, 1891.

III.—THE FAUNA OF THE OLENELLUS ZONE IN WALES.

By HENRY HICKS, M.D., F.R.S., Sec.G.S.

IN his recently published excellent Memoir on the "Fauna of the Lower Cambrian or Oleuellus Zone,"[1] Mr. Walcott has referred briefly to the presence of the fauna in Wales. The following additional facts bearing on the question may therefore be of some interest, and they will, I think, show that there is strong evidence in favour of the conclusion arrived at, that the Olenellus fauna occurs in the Caerfai Group of St. Davids, and in beds at the same horizon in North Wales.

South Wales.

In the year 1871, in a paper printed in the Q.J.G.S, vol. xxvii. p. 399, I described and figured some fossils which I had discovered near the base of the Lower Cambrian Rocks at St. David's. They were *Lingulella primæva*, *Discina pileolus*?, *Leperditia*? *Cambrensis*, and "part of the head of a Trilobite from a bed at the base of the purple rocks about 3000 feet below the Menevian Group" (*i.e.* in the beds immediately following the basal Cambrian Conglomerate, which rests unconformably on the Pre-Cambrian rocks). The Trilobite (head) (fig. 18, pl. xv.) was too indistinct for identification, and I refer to it now mainly to note the interesting fact that a Trilobite had been discovered at that time at the very base of the Cambrian at St. David's. What, however, has proved since to be of more importance was the discovery, about the same time, in a highly cleaved red slate near the same horizon, of several small fragments which I recognized to be portions of a Crustacean, but which I then incorrectly associated under one name in my description of *Leperditia*? *Cambrensis*. These fragments and others I have since obtained have now satisfied me that they are portions of heads of a species of *Olenellus*. In referring to them I said that some of the specimens "show a reticulated ornamentation." This form of ornamentation of the surface has now been shown by Professor Schmidt,[2] Mr. Walcott, and others to be characteristic of *Olenellus*. I am hoping that, ere long, another zone may be discovered, in beds which have suffered less from cleavage, and that it might be possible to give specific identifications, but at present it is only possible to say that the genus does occur there, and that the horizon of the fauna is very near the base of the series. As this fauna is separated by about 1000 feet of red and purple sandstones and slates from the next overlying fauna (*Plutonia Sedgwickii* and *Conocoryphe Lyellii* zone), it is quite possible that other zones, containing different species, may occur between, for in the higher beds containing *Paradoxides* each important zone is characterized by a new species. In the Cambrian succession at St. David's the most marked changes in the sediments occur almost immediately below the *Plutonia* beds, and at the top of the Menevian, but the greatest palæontological break is undoubtedly at the close of the Menevian. This tempted me in former papers to divide the Cambrian at St. David's into an Upper and a Lower division only, but as, at present, there seems to be a desire to make a threefold division, there can be no serious objection to restricting the terms Lower Cambrian to the Caerfai Group (*Olenellus* fauna), Middle Cambrian to the Solva and Menevian Groups (*Paradoxides* fauna) and Upper Cambrian to the Maentwrog, Ffestiniog, Dolgelly and Tremadoc Groups. I may here mention that the sandstones at the top of the Menevian, which yielded *Orthis Hicksii* and other Brachiopods, are now known to contain a *Paradoxides*, probably a new species, and a new species of *Conocoryphe* (which I hope to describe shortly). This somewhat extends the range upwards of *Paradoxides*, but the genus is still confined within the limit of the Menevian Group.

---

[1] Extract from the Tenth Annual Report of the Director of the U.S. Geological Survey, Washington, 1890.

[2] "Ueber eine Neuentdeckte Untercambrische Fauna in Estland," St. Pétersbourg, 1888.

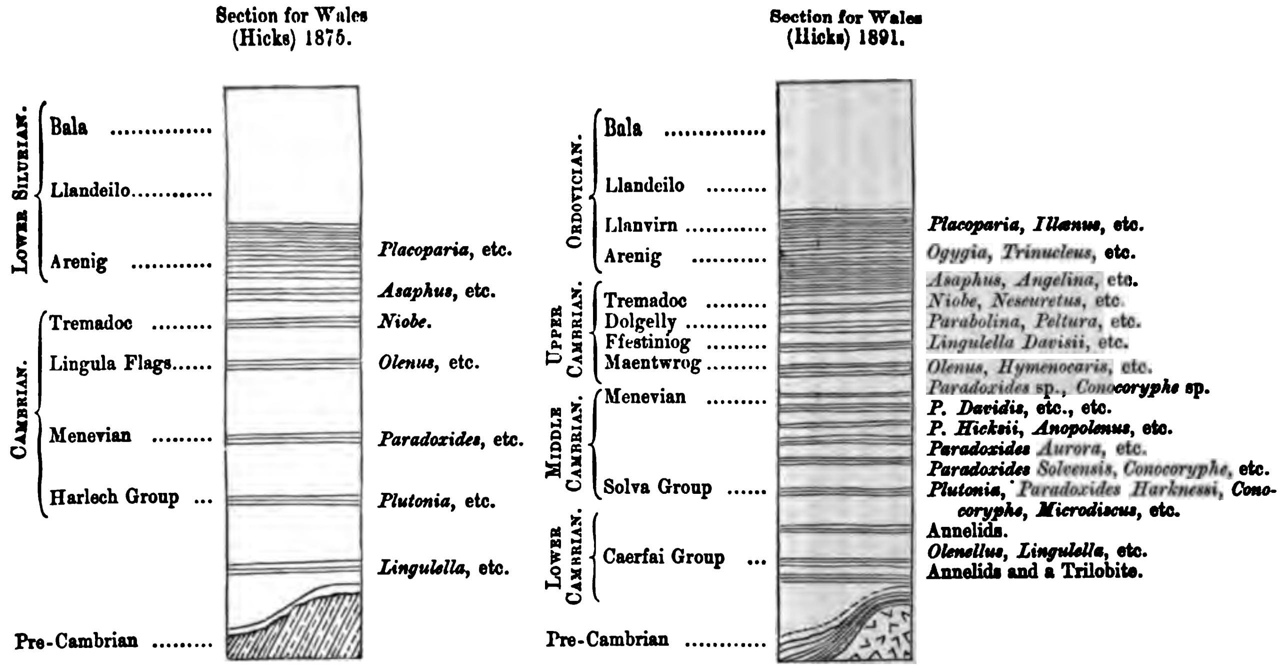
North Wales.

After referring to the fossils found in the Lower Cambrian rocks of St. David's, Mr. Walcott says (p. 580): "These, with the species from North Wales, described by Dr. Henry Woodward[1] as *Conocoryphe viola*, do not prove the presence of the *Olenellus* zone; but the weight of stratigraphic evidence is so strongly in favour of including them in its fauna that I shall do so. In the summer of 1888 I visited the locality of *Conocoryphe viola*, and found fragments of it associated with a species of *Hyolithes*." Mr. Walcott's visit was made during the excursion of the International Geological Congress, which I conducted to the Penrhyn Slate Quarries, in 1888. The position of this fossil is given in the "Explication des Excursions," p. 38, as near the horizon of the *Plutonia* and *Conocoryphe Lyellii* zone at St. David's; but it is quite possible that it might be somewhat lower than that horizon, though evidently higher than the *Lingulella primæva* zone. Most of the red and purple slates occur below the *C. viola* zone, and there are evidences of fossils in these beds. The succession in the Cambrian rocks at Penrhyn, Llanberis and in the Harlech Mountains, so nearly resembles that at St. David's that it has been possible to indicate the position in those areas of all the main zones found at St. David's, and at present it only remains for them to be worked out.

The following section contains the chief fossiliferous zones which are now known to occur in the Cambrian rocks of Wales, and by its side I place a section which was given for Wales in my paper

---

[1] Quart. Journ. Geol. Soc. vol. xliv. p. 74.



Chief fossiliferous zones now (1891) known to occur in the Cambrian rocks of Wales, compared with those known in 1875.

"On the Physical Conditions under which the Cambrian and Lower Silurian Rocks were probably deposited over the European Area," in the Q.J.G.S. for 1875, which has been reproduced by Mr. Walcott, along with the map and sections for other European areas, in his monograph. The main lines of division and zones remain as given in that section, but it has since been possible to make several important sub-divisions and to add new zones.[1]

The information obtained since the Map was published has confirmed the view I expressed in the paper that wherever the base line of the Cambrian is seen throughout the European area, it is almost invariably found to "rest unconformably upon an earlier series of rocks," and that the beds varied in thickness and character in accordance with the unevenness of the old pre-Cambrian floor and along fairly well-marked lines of depression. It is not, of course, to be expected that there should be an unconformable break between the Cambrian and Pre-Cambrian in all parts over a very large area, and Mr. Walcott shows that there is conformity at that horizon in several districts in America. In future the faunas must determine the position where there is any doubt as to the presence of a physical break. In Britain fortunately there is evidence of a very marked break at the base of the Cambrian in all the areas examined.

IV.—READE'S THEORY OF MOUNTAIN-BUILDING.

By A. J. JUKES-BROWNE, B.A., F.G.S.

MR. MELLARD READE'S book on the "Origin of Mountain Ranges" has now been before the geological public for five years; it has been reviewed in this MAGAZINE and elsewhere, and several more or less weighty objections to the theory have been put forward; but no very complete examination of it has been attempted. This may be partly due to the manner in which Mr. Reade has presented his theory, for he has certainly been too diffuse over points which require very slight illustration and not nearly explanatory enough on other points of great physical difficulty.

Having had occasion to pay some attention to the subject, it has seemed to me that some of the difficulties raised by some of his critics are not so great as they imagine, while there are other difficulties which neither Mr. Reade nor his critics have sufficiently considered. It may seem rather presumptuous on my part to enter a field of controversy where such men as O. Fisher, C. Davison, and M. Reade, are the debaters, and where the chief weapons used —physics and mechanics—are such as I have small acquaintance with. But some of the questions dealt with can be handled without more than an elementary knowledge of these subjects, and I fancy there are many geologists who wish to know exactly how far Mr. Reade's theory can be accepted as a *vera causa*. In what follows, therefore, I am only endeavouring to assist in forming a conclusion on this point.

---

[1] See "The Classification of the Eozoic and Lower Palæozoic Rocks," Popular Sci. Rev. 1881, and "Recent Researches among Lower Palæozoic Rocks," Proceed. Geol. Assoc. vol. vii.

In the first place I will deal with three objections which seem to me to be capable of being partially answered:

1. Mr. Fisher, reviewing the book in this Magazine,[1] criticizes Mr. Reade's conception of the physical state of the material below the crust: the wording of the passage quoted from Mr. Reade's book that this material is "solid by compression, but ready to flow one way or other, as the pressure may be reduced or increased," is certainly loose, but the context plainly shows Mr. Reade's conception of the material at about thirty miles depth to be that it is *permanently plastic*, and only kept from liquefaction by the pressure of a thirty mile crust above it. If the pressure were *relieved*, it would become liquid; if *everywhere increased*, it would become rigid; but if the plastic zone is deep, and a small area of the crust is weighted and depressed, the plastic material beneath may be displaced (without being made to flow as a liquid) and might have the effect of slightly bulging up the crust around the depressed area. This is Mr. Reade's view, but his use of the word *flow* suggests the idea of the liquidity which he did not mean to convey.

2. Mr. Fisher finds a second difficulty in the fact that the transference of heat from the plastic magma to the depressed crust would take place concurrently with the depression, "so that the swelling up (by expansion) would begin at once." Mr. Reade's own reply to this (Phil. Mag. 1891, p. 491) does not seem very happy: his own book (pp. 93 and 122) affords a better answer; for he says the first accession of heat would be employed in lateral expansion, and in folding and crushing the materials of the crust which underlay the newly-deposited sediments. He thinks the expansion of the lower layers of the weighted crust, being confined by the surrounding tracts and by the weight of the upper layers, would develope internal strains, and that much of the heat would be expended in doing work, *i.e.* in developing a force which would ultimately produce foliation by a process of forcible detrusion, crushing and repacking or reformation of constituents, when at length it became easier for the expansive force to lift the overlying mass of the crust rather than to exercise further lateral compression.

The above are Mr. Fisher's two principal objections to the theory of upheaval by cubical expansion, and he afterwards says, "If the two preliminary difficulties can be disposed of, the theory seems well suited to explain the formation of elevated plateaux. But for producing the intense corrugation, which characterizes most mountain ranges, the amount of horizontal expansion which it affords appears inadequate." In this remark I quite agree with him for reasons which will appear in the sequel.

3. Before, however, we can accept Mr. Reade's theory as a real cause of upheaval, we have to reckon with Mr. Davison, who has published what he regards as a fundamental objection to the theory.[2] He writes, however, as if it was the accumulating sediment only that received an accession of heat, and as if the crust below did not partake in this accession. He says the heat which expands the

---

[1] Dec. III. Vol. IV. p. 229, 1887.

[2] Geol. Mag. May, 1891, p. 211.

sediments must be withdrawn from the crust below, that this crust losing heat will contract, and that the expanding sediment will follow a retreating crust, so that no upheaval will take place at all, the total volume of crust and sediment remaining unaltered.

But these are not the conditions of Mr. Reade's theory.[1] The crust is depressed by the weight of sediment, and it is the lower part of the original crust which is the first to expand by receiving heat from below. It is true that this only transfers the application of Mr. Davison's argument; the heat is conveyed from one layer to another, and if the crust is receiving heat from the plastic under-stratum, the latter will be cooled and lessened in volume *unless its loss is made good.* But what is to prevent the loss from being made good?

Mr. Fisher has a remark on this point which is quoted by Mr. Davison, though he avoids the consideration of it. Mr. Fisher observes that "there can be no absolute increase in the amount of heat beneath the area in question except such as is supplied to it laterally."[2] This means that in his opinion some heat could be supplied laterally, and that heat lost by one part of the interior will be made good by the conduction of heat from the surrounding parts until the temperature of the whole is equalized; this may be a slow process, but it is surely a correct view, and one that Mr. Davison is bound to consider.

If the local loss of heat is thus distributed over the whole internal mass of the earth, there will be an absolute increase in the amount of heat below the sinking area, because the heat gained will be localized in the thickened crust. This thickened crust, composed partly of ancient crust material and partly of recent sediment, will expand; but how, in what manner, and to what extent, will it expand? These are the questions now before us.

Mr. Reade assumes that as soon as the depressed tract of crust begins to expand, the expansion will be localized and will form a ridge parallel to the longer diameter of the depressed area. He rests this belief on the results of certain experiments and observations made on the expansion of metal plates which did so ridge up when heated. But the conditions of these experiments did not resemble those of a weighted crust free to bend downwards, and consequently they do not afford a sound basis for his relief.

The ridging up of the leaden floor of a pantry-sink exposed to alternate expansions and contractions by the contact of hot and cold water; or the heating of a sheet of lead which is *screwed down* to a block of wood, cannot afford any clue to the manner in which expansion would occur in a *lenticular* mass of material, heated from below, slowly sinking and able to expand in almost any direction, but especially in any upward direction. Without closely imitating these conditions, it is impossible to say how such a mass would accommodate itself to the stresses set up by expansion, but it does not seem likely that a mass which is thickest in the centre would "buckle" or ridge itself up along a continuous diametric line; one would think that it was more likely to develope a set of concentric ridges near the edges, if any such ridges were produced at all.

---

[1] Mr. Davison informs me that his note had no special reference to Mr. Reade's book, but was simply a criticism on the "fundamental principle" of the expansion theory.

[2] Physics of the Earth's Crust, second edition, p. 123, repeated from the first *edition of 1881.*

It is quite possible that the crust below such a mass, being held circumferentially by the solid crust around it, would expand within its own area, and the internal compression resulting from this expansion might well produce some plication of the component rock-beds; the expansion would be greatest where the depression was greatest and the combined crust and sediment were thickest, but the plication would be greatest where the mass was thinnest and weakest, and there is no apparent reason why any part should throw itself into a great surface earth-wave; yet that is what Mr. Mellard Reade assumes it would do!

Again, if the expansion could be, or were likely to be, so localized as to cause a gigantic and continuous plication of the crust, the bending is not likely to be entirely upwards. Mr. Reade begins with assuming a plastic substratum; but when he comes to consider the expansion of the crust, he appears to assume a foundation which is rigid enough to support that crust without yielding to pressure. In all probability the compression which would cause an upward anticlinal swelling would force some other part of the bending crust still further downwards into the plastic substratum, and the most probable result would be a central anticline flanked by smaller synclinal plications. It is true that the total extent of the downward displacements would probably be less than that of the upward bulge, but any downward displacement will detract from the available upward expansion, and Mr. Reade requires all he can get for his mountain-building.

One of the most suggestive parts of Mr. Reade's book is his theory of plication by internal expansion (chapter xv.). He points out that if the corrugations of mountain chains have been formed by a compressive force *acting from outside the orographic area*, then the corrugated beds must originally have occupied a much wider space, the space in fact which they would now cover if pulled out straight. This is assumed by most geologists, and, taking it for granted, they have calculated that the breadth of country now occupied by the Alps has been *shortened* by 72 miles, and that occupied by the Appalachians has been shortened by 88 miles, that is to say, two spots, one on each side of the Appalachian Mountains, have been brought nearer to one another by 88 miles, and Mr. Reade asks whether geologists have fully realized what this means.

If, on the other hand, the plications are due or even largely due to the compression produced by the internal expansion of the mass, they result from actual lengthening of the strata throughout the whole breadth of the orographic area, and consequently they do not involve any lateral movement in space. This seems to me a point that is well worth consideration.

It is a question, however, whether the plications are wholly formed by expansive compression; if they are, then they become a measure of the expansion. Now in the case of the Alps the calculated shortening is nearly as great as the actual width of the range; in other words, the expansion must have doubled the length of the beds laterally; to do this it must have doubled the volume of the solid mass out of which the range was formed. Let us apply this result to an area of the size used by Mr. Reade for illustrative calculation, viz. one measuring 500 × 500 × 20 miles, which is equal to 500,000 cubic miles. Now if this is doubled by expansion, 500,000 cubic miles has been added to the mass, but the calculated expansion of such a block raised by 1000° F. is only 78,400 cubic miles, and is therefore very far short of the required amount. The conclusion I would draw from this little calculation is that the plications are not wholly due to expansion.

Finally, it seems desirable to point out to Mr. Reade that the assumption of a plastic substratum will not satisfy Sir W. Thomson's demands for the rigidity of the Earth as a whole. Mr. Reade cannot have a substratum that is plastic enough to yield to such a small terrestrial influence as the local accumulation of sediment, while it is rigid enough to resist the deforming tidal influences of the sun and moon. The only way out of this difficulty is the assumption of a liquid substratum saturated with dissolved gas: this is Mr. Fisher's view, and it affords a much more satisfactory basis for the explanation of terrestrial movements.

Postscript.—Correspondence with Mr. Davison leads me to see that although the temperature of the mass below the depressed area will be raised by conduction of heat from the surrounding parts, yet that these surrounding parts will contract in parting with heat; consequently if this conduction is fairly rapid and the further equalization of temperature is a slow process, the mass which is receiving heat may expand laterally into the spaces formed by the contraction of the parts immediately outside it, instead of expanding upwards and raising the depressed crust. Mr. Davison therefore still maintains that no upheaval would result from the expansion of a depressed portion of the crust, and until his argument can be answered it certainly cuts at the root of the expansion theory of surface upheavals.

V.—ON THE OCCURRENCE OF *XANTHIDIA* (*SPINIFERITES* OF MANTELL) IN THE LONDON CLAY OF THE ISLE OF SHEPPEY.

By E. W. WETHERELL, F.G.S.

THE vexed question of the affinities of the fossil organisms known as *Xanthidia*—a question which only experienced zoologists and botanists can hope to solve—will not be discussed in this short paper, my intention being merely to show that these interesting organisms are not confined (in England) to the Chalk flints and *Grey Chalk, but exist* in the London Clay, and to give a short account of the means of isolation and of the appearance of these minute fossils.

I may here mention that all writers[1] previous to Mr. Henry Deane speak of them as spherical bodies; but these earlier observers, including the discoverer Ehrenberg, had only examined fossil *Xanthidia* in chips of flint; whereas Mr. Deane[2] succeeded in isolating them. Mr. Deane took a fragment of Grey Chalk, obtained from the beach between Folkestone and Dover, and dissolved it in hydrochloric acid, and in the residue he discovered these organisms—which he describes as not being true spheres, but somewhat flattened, having a remarkable resemblance to some gemmules of sponges, and having a circular opening in one of the flattened sides. Mr. Deane adds that on submitting some individuals to pressure between glass plates, they were torn asunder laterally like a horny substance, and the spines in contact with the glass were bent, while some specimens after soaking in water became flaccid showing that they were not siliceous.

Having thus briefly described Mr. Deane's results, I will proceed to the description of the London Clay forms and the method of obtaining them.

My attention was first called to them in the finer siftings of the washing of clay obtained from the cliff near Minster, Sheppey. This clay I obtained at a height of about four feet above the beach, and it is of a greenish colour—all the clay above and below being brown and much more compact. A great number of organisms can be seen in this clay without the aid of a magnifying-glass, whereas the brown clay contains few fossils.

The first specimens of *Xanthidia* found were very much damaged, so I altered the method of washing in the following way. The clay was disintegrated on a piece of perforated zinc immersed in water, and after an hour or so the zinc was gently shaken and all the finer particles went through, leaving the larger fossils, such as Gasteropods, vertebræ, and teeth of fishes, etc., on the zinc, which was then removed, and the finer material was again sifted in the wet state through a wire sieve 90 × 90 holes to the square inch; this separated out the larger Foraminifera (which exist in this deposit in great numbers of the genera *Cristellaria*, *Marginulina*, *Nodosaria*, etc.), and the finest material was then washed and dried in the ordinary manner, and gave far better results than the material resulting from washing in the ordinary way. A microscopical examination of this finest sifting showed a great number of *Xanthidia*, which for the most part follow two types which can be easily distinguished, although there are a great many minor varieties of each of them. In many cases these organisms are found joined together, in pairs or with five or six individuals massed together.

Their characters are as follows: shape, lenticular; some specimens far flatter than others, but this may be due to pressure; in some the spines (tentacula of White)[1] appear to be round the edge, and also springing out obliquely from the flattened sides, and in others they appear to be round the edge only. The flattened surface of the organism is very variable in shape, sometimes almost truly circular, in other cases elongated, and often very irregular in contour.

---

[1] Ehrenberg, 1836, Bericht. des Akademie Wissenschaften zu Berlin, p. 114.—*vide* also Abhandlungen Konigl. Akad. Wissenschaften zu Berlin, 1836 (published 1838), p. 114.—Turpin, Comptes Rendus de l'Académie des Sciences, 1837.

[2] Micros. Soc. Trans. Oct. 15th, 1845, vol. ii. p. 77.

The length, thickness, and number of these spines varies very considerably, giving rise to the two types above referred to. One type has the central body-portion circular and small with a large number of regular radial spines, almost as long as the diameter of the body portion, and very thin, the ends much branched. The other type has a much larger body, more irregularly shaped, fewer, shorter and thicker spines, which branch out very irregularly, crowded together in one part and scanty in other parts.

When viewed by reflected light, *Xanthidia* appear to be white, or pale brownish, and the spines are transparent. If seen by transmitted light, however, when mounted in glycerine, the body portion becomes more or less translucent, and is of a distinct green colour. This greenish body contains black spots, and in some few cases the whole body, except the very edge, is opaque. Glycerine shows the whole form better than any other medium, Canada Balsam having an index of refraction which prevents the spines being seen. These spines can be bent by pressure when wet.

Saffronine stain was taken up by the body, but the spines were but little affected.

The diameter of these minute organisms is about $\frac{1}{10}$ mm., coinciding exactly with the measurement of the Chalk forms.

With reference to the greenish clay which contains *Xanthidia*, I should mention that it is not a distinct bed or band, but a patch, and contains great quantities of fish-remains (vertebræ, spinous processes, otoliths, scales, etc.), besides the Mollusca and Foraminifera. Although a patch, it occurs in a band of somewhat laminated clay, which I have traced for several hundred yards along the cliffs, in which occur other fossiliferous patches, which do not contain *Xanthidia*, as far as I have been able to see, although I have examined several samples. The *Xanthidia* patch, as I found it, was about a yard long, some three or four inches thick, and extended about eighteen inches or possibly farther, into the cliff; but near that point the clay appeared less fossiliferous to the naked eye, and was probably at the end of the patch.

I wish to mention that, through the kindness of Prof. Judd, the work in connexion with this paper was performed in the geological laboratory of the Royal College of Science, South Kensington.

---

[1] H. H. White, Trans. Micros. Soc. vol. i. p. 77, on Fossil *Xanthidia*, Feb. 1842.

NOTICES OF MEMOIRS.

I.—ÉTUDE MICROGRAPHIQUE DU TUFFEAU À *CYPRINA PLANATA* DU NORD DE FRANCE ET DE LA BELGIQUE. DU ROLE DES DIATOMÉES DANS LA FORMATION DE CE TUFFEAU (Notice préliminaire). Par M. L. CAYEUX, Préparateur de Géologie à la Faculté des Sciences de Lille. Annales de la Société géologique du Nord, t. xix. 1891, pp. 90–95.

THE Tuffeau described in this paper is a rock consisting of glauconitic sands agglutinated together by a siliceous cement, which is of not infrequent occurrence in the Sands of Landenian age in many localities in the North of France and in Belgium. The horizon of *Cyprina planata* appears to be slightly lower than that of the Thanet Sands of this country. In some places, near Lille for example, the rock is remarkably rich in zircon, tourmaline and rutile. The author has also discovered therein abundant remains of Diatoms and sponge-spicules; the former principally belong to the genera *Synedra, Coscinodiscus* and *Triceratium*, whilst the latter are chiefly of Monactinellid and Tetractinellid sponges. Sometimes the Diatoms prevail in the rock; at others the spicules. The silica forming the cement of the rock may be either in the condition of opal or chalcedony, and thus resembles the silica of the organisms. The author considers that this cementing silica has, in part, if not altogether, been derived from the remains of the diatoms and sponges. In a subsequent note in the same journal (p. 134) mention is made of the occurrence of Diatoms in the upper portion of the Ypresian of Flanders, thus on the horizon of the London Clay. From the character of the minerals in the Tuffeau and sands of the Lower Eocene, the author concludes (p. 265) that they have been primarily derived from the crystalline-schist series of rocks.

G. J. H.

II.—PALÆOZOIC FOSSILS FROM KOTELNY ISLAND, NEW SIBERIA. By Baron EDUARD VON TOLL. Mémoires de l'Académie Impériale des Sciences de St.-Pétersbourg, viie série, vol. xxxvii. No. 3, 1889.

THIS is the first portion of the Scientific Results of the Expedition sent out in 1885–6 by the Royal Academy of Sciences for the Exploration of Jana-Land and the New-Siberian Islands. Prefatory remarks (pages 1–9) give an account of the Expedition, its aim, progress, members, and helpers. A description of the fossiliferous Devonian strata of the West Coast of Kotelny Island (pages 10–13) precedes that of the fossils, which comprise 23 species and varieties of Brachiopods, 6 Corals, and 2 Stromatoporoids. Eight forms are peculiar to this region, and a table at p. 32 shows the distribution of the others in Siberia, West side of the Ural, Petchora-land, Rhine-land, North America, or China, in the upper division of the Middle-Devonian formation.

The Silurian fossils, chiefly from the gravel of the Ssrednjaja river, are 7 Brachiopods, 4 Trilobites, 6 Ostracodes (*Leperditia*), 12 Corals, 1 distinct (*Lagena*) and 5 indistinct sections of Foraminifera. The distribution of these species in the Upper-Silurian formations of Siberia, Estland and Oesel, Scandinavia, Britain, China, and America is shown in a table at p. 55. *Strophomena euglypha, Phacops quadrilineata, Favosites Gotlandica, F. Forbesi, Alveolites Labechei, Heliolites interstinctus*, and *Halysites catenularia* have the widest range. Five quarto plates of numerous figures illustrate this interesting memoir.

T. R. J.

REVIEWS.

I.—THE FAUNA OF THE LOWER CAMBRIAN OR OLENELLUS ZONE. By CHARLES DOOLITTLE WALCOTT, F.G.S., of the Smithsonian Institution, Washington, D.C., U.S.A. Extract from the Tenth Annual Report of the Director (1888–89). Washington, 1890 (issued 1891). U. S. Geological Survey. 4to. pp. 511–774, Plates xliii.–xcviii.

THE publications of the Geological Survey of the United States of America have long been famous for their illustrations and their typography; for the vast amount of economic information they contain as regards the stratigraphical geology, the physical features, the agricultural and mineral resources contained in each State. Nor has science been neglected, for there are but few volumes, out of the long and splendid series already issued, which have not contained most valuable contributions to the palæontology of some group of organisms, or the fauna of some series of rocks. This is all the more honourable to the present Director, Major J. W. Powell, because it is an open secret that, *like Gallio, "he cares for none of these things,"* and might, if ungenerously disposed, have placed great obstacles in the way of the progress of palæontology. We have now to thank him for enabling Mr. C. D. Walcott, the author of the memoir before us, to bring out in a suitable manner, one of the finest pieces of work which has issued from the Government Printing Office, Washington, already famous for its productions, so generously distributed by the United States Government to men of science all over the world.

The author, with the modesty of true merit, prefaces his work (pp. 516–524) with the names of some forty authors and over one hundred papers bearing upon Cambrian geology and palæontology. Mr. Walcott thus defines the title of his work:—

"A living fauna, as known to the zoologist, is the assemblage of animals embraced within a given geographic province or area, and includes all animal life associated on account of climate or physical boundaries. Some of the species may range from province to province and form a part of several faunas, while others are limited to a particular portion of some faunal area.

"In the study of the extinct faunas, buried in the rocks, the same general principles of classification prevail, with the added restriction of vertical or time range as defined by the progressive zoologic changes in the faunas.

"There is not a sufficient assemblage of species found in the oldest rocks in which animal life has been detected to constitute a fauna that can be characterized either as distinct from the succeeding fauna or as belonging to that fauna. At present the first recognized fauna occurs in the lowest division of the Cambrian group. In nearly all the localities where this lowest zone is recognized a peculiar genus of Trilobites, *Olenellus*, is found; and thus the name 'Olenellus fauna' and 'Olenellus zone,' have come into general use. By the palæozoologist the fauna is called the Olenellus or Lower Cambrian Fauna. To the geologist the series of rocks in which the Olenellus fauna occurs is known as the lower division of the Cambrian group or 'Olenellus zone'" (p. 515).

In addition to a most valuable list, already referred to, of all the more important books and papers relating to the subject, the author gives a historical review of the work done on the rocks and fossils included in the Olenellus zone, and the general results of the study of the fauna by the geologist and palæontologist, or its physical biological history and character as far as is known.

The geologist considers it as found in certain rocks at a distinct geologic horizon and studies its geologic relations. The palæozoologist treats of it in its relations to the animal world, past and present.

Mr. Walcott first traces back the history of the Lower Cambrian strata in America to 1818, when Prof. Amos Eaton first gave them a definite position in the series of stratified rocks. Passing in review the records of each writer, he shows the gradual development of the history of this series of rocks and gives the ancient and modern nomenclature by which it has been distinguished, and the areas over which it has been observed.

Mr. Walcott shows that the Lower Cambrian, or Olenellus fauna, lived along the shores of the pre-Cambrian continent which from east to west was almost co-extensive with that of the N. American continent of to-day. That it has been observed in the north-west at Mount Stephen, British Columbia; at Eureka district, British Nevada; in Northern Arizona, in the Grand Cañon of the Colorado; on the western slope of the Wasatch Mountain; on the Gallatin River, Montana; on the Black Hills of Dakota; in Wisconsin and Minnesota; on the Ozark Mountains, Southern Missouri; and even as far south as Llana County, Texas; in Eastern Tennessee; Eastern and Northern Adirondack Mountains of New York; and Green Mountains; North Attleborough and Braintree; at St. John's, New Brunswick, far northwards; at l'Anse au Loup, N. side of Straits of Belle Isle, Labrador; and lastly in the extreme N.E. at Conception Bay, Avalon Peninsula, Newfoundland.

All this is graphically illustrated by a map (pl. xliv.), and by very numerous sections and plates (pl. xlv.–xlvii.).

Plate xlviii. shows in the same graphic method the extension eastwards into Europe of probably the same series of unconformable pre-Cambrian rocks on which the Cambrian series rest. These are shown in Spain, in Wales (North and South); and we may now add the North-West Highlands; in Norway and Sweden; in Finland; in Bohemia and Bavaria; in Sardinia; in Podolia; in Petchora land and the Ural Mountains. Perhaps the most astonishing part of this new page of early geological history, to the deciphering of which Mr. Walcott has brought such skill and ability, is that which relates to the fauna, the mere names of which, in column, fill four pages. Here is the summary, written in a very compact manner by the author (p. 576).

RESUME OF THE FAUNA OF THE OLENELLUS ZONE IN AMERICA.

CLASSES, ETC.	NUMBERS.		
	Genera.	Species.	Varieties.
Spongia	4	4	0
Hydrozoa	2	2	0
Actinozoa	5	9	0
Echinodermata	1	1	0
(Trails, Burrows, and Tracks)...	4	6	0
Brachiopoda	10	29	2
Lamellibranchiata	3	3	0
Gasteropoda	6	13	5
Pteropoda	4	15	2
Crustacea	5	8	0
Trilobita	15	51	2
Total	59	141	11

Uniting all the fossils of this zone found by our English geologists, Drs. Hicks, Lapworth, etc., in Wales and Shropshire; by Dr. Schmidt in Russia; by Profs. Kjerulf, Linnarsson, Torell, Brögger, Holm, Nathorst, and others in Sweden and Norway, and those from the other European localities, the numbers are extremely small, at present, when compared with those recorded on the American Continent; nevertheless the facies is one that clearly admits of perfect correlation.

Mr. Walcott is also able satisfactorily to show now that the *Olenellus* fauna *preceded* the *Paradoxides* fauna. "The cause of the abrupt change from the *Olenellus* to the *Paradoxides* faunas is not yet fully recognized. While a considerable portion of the genera pass up, very few of the species are known to do so, and in none of the sections has there been found a commingling of the characteristic species of the Lower and Middle faunas" (p. 594).

"If we attempt to classify the *Olenellus* fauna by its genesis, an almost impenetrable wall confronts us. That the life in the pre-*Olenellus* seas was large and varied there can be little, if any, doubt. The few traces known of it prove little of its character, but they prove that life existed in a period far preceding Lower Cambrian time, and they foster the hope that it is only a question of search and favourable conditions to discover it. As far as known to me, the most promising area in which to search for the pre-*Olenellus fauna is on the western* side of the Rocky Mountains in the United

States, and on the eastern slopes in British Columbia. There the great thickness of conformable pre-*Olenellus* zone strata presents a most tempting field for the student-collector" (p. 595).

As the author remarks, a considerable number of the genera and species included in this Monograph have already been described at length and figured in Bulletin No. 30 of the U. S. Geological Survey (1886). Beginning with the sponges, which are by no means numerous, we find Salter's genus *Protospongia* represented by detached spicules of the usual type, and portions of the anchoring rope of another hexactinellid sponge, similar to those usually referred to *Hyalostelia*, Zittel, have been placed by the author in a distinct genus, *Leptomitus*. It may be remarked that since the discovery, by Sir J. W. Dawson, that certain species of *Protospongia* possessed anchoring spicules, it is not improbable that forms like this *Leptomitus* may be found to belong to the former genus. The above are the only definite sponges known from the Lower Cambrian, for the specimens of *Girvanella*, even if they really belong to this genus, have no claim to be considered as sponges, and they are now believed to be calcareous algæ. The position of another new form, *Trachyum vetustum*, appears to be very uncertain, the description leads one rather to consider it a member of the next group of the Archæocyathinæ. This group is very fully represented in the Lower Cambrian of Nevada, New York and Labrador, and very good figures are given to illustrate the structure of the different genera. The author follows Hinde in placing these peculiar forms in the Actinozoa. Very considerable interest attaches to them, since they appear to be characteristic of the Lower Cambrian, not only in America, but in Spain and Sardinia, and, as lately shown by R. Etheridge, jun., in South Australia as well.

Of the fine series of plates which illustrate the fauna of the *Olenellus* or Lower Cambrian Zone, plate xlix. is devoted to *Leptomitus Zittelli* and *Protospongia* sp.? two forms of Sponges; plates l.–lv. to a series of figures of different forms of the Archæocyathinæ, in some of which structure and ornament are preserved. Plates lvi.–lix. to forms referred to the Hydrozoa. Plates lx.–lxvi. to Echinodermata, Annelida, and Crustacea, being tracks, trails, and Annelide- and Crustacean-burrows of all kinds. Plates lxvii.–lxxii. are devoted to a series of Brachiopods—*Lingulella, Acrotreta, Linnarssonia, Kutorgina, Iphidea, Acrothele, Mickwitzia, Obolella, Camarella, Orthis,* and *Orthisina,* mostly well-preserved and well-defined species. Then follow plates lxxiii.–lxxiv., devoted to Lamellibranchs and Gasteropods, in which Patella-shaped forms predominate. Plates lxxv.–lxxix. are devoted to Pteropods (under which are included *Salterella, Hyolithes, Helenia, Coleoloides, Volborthella,* and *Platysolenites.* The remaining plates, pls. lxxx.–xcviii., are devoted to the Crustacea, and principally to the Trilobites. A few Ostracods and *Leperditia*, with *Agnostus* and *Microdiscus*, occupy plates lxxx. and lxxxi., followed in the remaining plates by a grand series of *Olenelli* which would have rejoiced the heart of J. W. Salter, could he but have lived to see and gloat over them. Trilobites—many of them at least—with the third thoracic segment drawn out into a long pleural spine on either side, giving them a most weird appearance (these are occasionally curled round, as in *Olenellus Gilberti*). In *Mesonacis Vermontana*, the abdomen is elongated into 12 or 13 segments, with a powerful median dorsal spine rising from the proximal segment, and reaching to the end of the body; in *M. asaphoides* there are five of these spines; in *Holmia Bröggeri* spines are present down the centre; the nuchal median spine being equal in length to nearly seven of the body segments.

This form is no doubt most nearly related to Professor Lapworth's *Olenellus Callavei*, but there are well-marked differences between them, when carefully compared, both in the head-shield, body-segments, and spines. *Olenellus* (*Mesonacis*) *Mickwitzii* and *O.* (*Holmia*) *Kjerulfi*, the former a Russian form and the latter from Sweden, suggest new departures in spines and tubercles and a facies diverging towards *Paradoxides* of the Middle Cambrian, but with marked differences. The spine, on the axis of the Russian form, reminds one of the genus *Cyphaspis*.

There is a common family-likeness in all these *Olenelli*, but they run through a great variety of form, amounting in some probably to generic value, as pointed out by Mr. Walcott. This is strikingly the case if we compare his *Olenellus Thompsoni* with *Olenellus* (*Holmia*) *Kjerulfi*, and *Olenellus Gilberti* with *Olenellus* (*Mesonacis*) *Vermontana* and *O.* (*Mesonacis*) *Mickwitzii*.

Sixty-one pages are occupied (pp. 597–658) with carefully prepared Notes on the genera and species of the fauna of the *Olenellus* Zone, and the work concludes with what all works should possess, namely, a good index.

We heartily congratulate the author upon having had the honour to bring together so admirable a Monograph upon a new or but little understood formation, which has apparently so remarkable a geographical range, and possesses such a well-marked fauna wherever it has been observed. Such discoveries in the geology and palæontology of the oldest Palæozoic rocks may well serve as an incentive to future workers, and clearly show that much yet remains to be done in order to complete our knowledge of the fauna of these ancient seas.

II.—A MONOGRAPH OF THE CARBONIFEROUS AND PERMO-CARBONIFEROUS INVERTEBRATA OF NEW SOUTH WALES. Part I. CŒLENTERATA. By R. ETHERIDGE, jun., Palæontologist and Librarian to the Geological Survey of New South Wales, etc. MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES. By C. S. WILKINSON, F.G.S., etc., Geological Surveyor-in-Charge. 4to. pp. ix. 64. Pls. I.–XI. (Sydney, 1891.)

THE Geological Survey of New South Wales, with the view of extending a knowledge of the coal-bearing formations in that colony, has determined to publish fresh descriptions of the invertebrate fossils in these rocks, which have been collected by the

Survey, and are now in the Mining and Geological Museum at Sydney, and the present work relating to the fossil Corals, by Mr. R. Etheridge, jun., Palæontologist to the Survey, is intended as a first instalment.

The subdivisions of the Carboniferous rocks of New South Wales are at present under revision; according to the arrangement provisionally adopted, the strata below the Farley Group of the Lower Marine Series are considered as Carboniferous simply, whilst this Lower Series and the Upper Marine Series, which are intercalated with the productive Coal-measures, are regarded as Permo-Carboniferous. In these rocks corals are, as a rule, scarce and poorly preserved, with the exception of species of *Zaphrentis* and the Monticuliporoid genus *Stenopora*. Of the former genus seven species are described, three of which, *Z. Culleni*, *Z. phymatodes*, and *Z.*? *sumphuens*, are new forms. Some of these exhibit a remarkable infilling of the calyx and thickening of the septa with sclerenchyma; features which are very prominent in *Plerophyllum*, Hinde, but as they do not show the 4 or 5 characteristic large septa of this latter genus, it may be doubted whether they can rightly be included in it. Other species described are *Lophophyllum corniculum*, de Kon., *Campophyllum columnare*, sp. nov., *Cyathophyllum* (?) *zaphrentoides*, sp. nov., *C. retiforme*, sp. nov., and *Aulophyllum Davidis*, sp. nov. Of perforate corals a new species of *Trachypora*, *T. Wilkinsoni*, is described, which, in many of its characters, resembles *Striatopora*; also *Michelinia* sp., allied to *M. tenuisepta*, Phillips, and *Cladochonus tenuicollis*, M'Coy.

A very full and elaborate description of the minute structural characters of the genus *Stenopora* is given, and the three species described by Lonsdale, *S. crinita*, *S. ovata*, and *S. Tasmaniensis*, are recognized, although the author is inclined to believe that they do not represent separate and distinct species, but merely different conditions, which seem permanent in certain circumscribed areas.

The investigations which have lately been made into the minute structure of *Stenopora*, and other Monticuliporoids, clearly show that these fossils possess a similar minute structure of their walls to forms which are generally recognized as Polyzoa, and if any value is to be attached to this similarity in microscopic detail, there is no doubt that *Stenopora*, in common with the other genera of this group, will no longer be able to rank as corals. Mr. Etheridge does not enter into this question, but follows the views of Nicholson, and of Waagen and Wentzel, that they are really allied to corals. In its massive mode of growth, a form like *Stenopora crinita*, which sometimes reaches six inches in diameter, certainly approaches in appearance more nearly to corals than to polyzoa; but on closer consideration this massive structure is seen to be built up of a series of layers which, in certain states of preservation, as remarked by Mr. Etheridge, peel off, one after another, leaving an entirely new surface after each operation. In the mass, *S. crinita* has a wonderful resemblance to the large *Chætetes radians* from the Carboniferous

Limestone of Russia, but microscopic sections of the two forms at once show that the structure of this latter is that of a coral, whilst the former is altogether distinct, and, as already mentioned, resembles that of generally recognized Palæozoic Polyzoa.

Without reckoning *Stenopora* with its three species, there are only nine genera and seventeen species of corals known in the Carboniferous rocks of New South Wales, a small number when compared with those of the corresponding formations in Europe, or with those of the Siluro-Devonian period of Australia.

Mr. Etheridge's descriptions are amply illustrated in the eleven plates accompanying this report, which at once sustains the reputation of the author, and bears witness to the enlightened encouragement of palæontological science by the Government of the Colony.

III.—ON THE PROBABLE NATURE AND DISTRIBUTION OF THE PALÆOZOIC STRATA BENEATH THE SECONDARY, ETC., ROCKS OF THE SOUTHERN COUNTIES; WITH SPECIAL REFERENCE TO THE PROSPECT OF OBTAINING COAL BY BORING SOUTH OF THE MENDIPS. By W. A. E. USSHER, F.G.S. [Proc. Somerset Arch. and Nat. Hist. Soc. vol. xxxvi. 1891.]

THE probable occurrence of productive Coal-measures on the southern side of the Mendip Hills has been discussed since 1826, when Buckland and Conybeare first wrote on the geology of that region (see GEOL. MAG. 1871, p. 500); but no one at present has put down any boring sufficiently deep to prove the nature of the Palæozoic floor over the area where these buried Coal-measures are likely to occur. The subject is treated from a broad point of view by Mr. Ussher in the paper under consideration. Referring to the Culm-measures of Devonshire, he points out that there is no reason to believe that the easterly development of this comparatively unproductive series, would affect the question of true Coal-measures being reached in the area south of the Mendips. The Culm-measures include representatives of the Carboniferous Limestone, Millstone Grit, and possibly [we would say probably] the lower part of the Coal-measures; but eastwards near Burlescombe and at Cannington Park the Limestone becomes more prominently developed, and it therefore is likely that further east and north-east the Carboniferous beds generally would approximate more and more closely to the characters they have in the Mendip area and in the Somersetshire Coal-field.

From a general consideration of all the facts, and especially with reference to observed dislocations in the older rocks of West Somerset, Mr. Ussher concludes that the most probable location of an underground Coal-basin in the area south of the Mendips, would be enclosed by an irregular line drawn from the coast near Otterhampton, through Pawlet and Meare, to Polsham; from Polsham to Wedmore, and thence by Badgeworth and Lympsham to the coast at Brean. Within this line the best sites for trial borings would be in the vicinity of Highbridge, Burnham, and Berrow; at East or South Brent, Chapel Allerton, Wedmore, Meare, and Mark. The depth of strata likely to cover the Palæozoic floor at these places might be expected to vary from four or five hundred to a thousand feet, but it is improbable that it would anywhere exceed a thousand feet.

In connection with the disturbances to which the Mendip area has been subjected, Mr. Ussher introduces a diagram to explain by means of a thrust-plane the occurrence of the little masses of Carboniferous Limestone that overlie the Coal-measures at Vobster on the northern side of the Mendip anticline. H. B. W.

REPORTS AND PROCEEDINGS.

◆

Geological Society of London.

I.—Nov. 11, 1891.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On *Dacrytherium ovinum* from the Isle of Wight and Quercy." By R. Lydekker, Esq., B.A., F.G.S.

The author described a cranium and mandible of *Dacrytherium Cayluxi* from the Quercy Phosphorites, which proved the identity of this form with the *Dichobune ovina* of Owen from the Oligocene of the Isle of Wight. The species should thus be known as *Dacrytherium ovinum*. It was shown that the mandible referred by Filhol to *D. Cayluxi* belongs to another animal.

2. "Supplementary Remarks on Glen Roy." By T. F. Jamieson, Esq., F.G.S.

The author discusses the conditions that preceded the formation of the Glen Roy Lake, and appeals to a rain-map of Scotland in support of his contention that the main snowfall in Glacial times would be on the western mountains. He gives reasons for supposing that, previously to the formation of the lake, the valleys of the Lochaber lakes were occupied by ice, and that the period of the formation of the lakes was that of the decay of the last Ice-sheet.

He supports the correctness of the mapping of the terraces by the officers of the Ordnance Survey, and shows how the absence of the two upper terraces in Glen Spean and of the highest terrace in Glen Glaster simplifies the explanation of the formation of the lakes by ice-barriers.

The alluvium of Bohuntine is considered to be the gravel and mud that fell into the lake from the front of the ice when it stood at the mouth of Glen Roy during the formation of the two upper lines.

During the last stage of the lake, the ice in the valley of the Caledonian canal is believed to have constituted the main barrier, whilst the Corry N'Eoin glacier played only a subordinate part.

The author suggests the possibility of a *débâcle* during the drop of water from the level of the highest to that of the middle terrace; and in support of this calls attention to the breaking down of the moraines of the Treig glacier at the mouth of the Rough Burn. He believes that when the water dropped to the level of the lowest terrace, it drained away quietly, at any rate until it receded from Upper Glen Roy.

In discussing Nicol's objections, he maintains that notches would not be cut at the level of the *cols*, and observes that the discrepancy between the heights of the terraces and those of the *cols* has probably been increased by the growth of peat over most of the ground about the watersheds.

The horizontality of the terraces is stated to be a fact, and cases are given where waterworn pebbles are found in connexion with the "roads," these being especially noticeable in places where the south-west winds would fully exert their influence, and the structure of the terraces is considered to be such as would be produced at the margins of ice-dammed lakes. Further information is supplied concerning the distribution of the boulders of Glen Spean syenite. These are found on the north side of the Spean Valley at the height of 2000 feet above the sea and 1400 feet above the river, and fragments of the syenite have been carried towards the north-east, north, and north-west.

In an Appendix, the author discusses Prof. Prestwich's remarks on the deltas, and his theory of the formation of the terraces.

II.—Nov. 25, 1891.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On the Os pubis of *Polacanthus Foxi.*" By Professor H. G. Seeley, F.R.S., F.G.S.

Hitherto the evidence of the systematic position of *Polacanthus* has not been very precise. The author has detected the missing pubis as an isolated specimen. This he regards as the anterior portion of the left pubis, and appends a full description of the bone. He furthermore gives a critical account of our knowledge of other pelvic bones of the genus, and is led to associate *Agathaumus*, *Cratæomus*, *Omosaurus*, and *Palacanthus* in near alliance, in the Scelidosaurian division of the Order *Ornithischia*.

2. "A Comparison of the Red Rocks of the South Devon Coast with those of the Midland and Western Counties." By Professor Edward Hull, LL.D., F.R.S., F.G.S.

The author believes, with Dr. Irving, that the Red Rocks of Devonshire are representatives of the Permian and Trias, which occupy so large a portion of the district bordering Wales and Salop, and which extend into the Midland Counties, and comments on the remarkable resemblance between the representative beds on either side of the dividing ridge of Palæozoic rocks which underlies East Anglia and emerges beneath the Jurassic strata in Somersetshire.

He believes that the breccia forming the base of the series in the Torquay district is a representative of the Lower Permian division, but differs from Dr. Irving, in assigning the red sandstones and marls of Exmouth to the Trias, and not to the Permian, as that author has done. He compares them with the Lower Red and Mottled Sandstones, and regards the Marls as of local origin, thus causing the beds to diverge from the normal type.

The Budleigh Salterton Pebble-beds, with overlying sandstones and pebbly beds, he assigns to the horizon of the Pebble-beds of the Midland area, and points out that fossils of Silurian and Devonian types occur in the pebbles of both areas.

The Upper Division of the Bunter is well shown at Sidmouth, and the author takes a calcareous breccia, two feet thick, which is found in the cliffs, as the basement bed of the Keuper division.

3. "Supplementary Note to the Paper on the 'Red Rocks of the Devon Coast-section,' Q.J.G.S. 1888." By the Rev. A. Irving, D.Sc., B.A., F.G.S.

In this note the author accepts Prof. Hull's determination (see above) of the breccia at Sidmouth as the base of the Keuper, and discusses the age of the sandstones containing vertebrate remains discovered by Messrs. Whitaker, Metcalfe, and Johnston-Lavis. He brings forward evidence in support of his view that these are really of Upper Bunter age, notwithstanding the character of the organisms.

He adds new material in support of his contention that the sandstones and marls which Prof. Hull assigns to the Lower Bunter are really Permian; but he is inclined to think that the breccias (in part, at least) pass laterally into the sandstones, and do not underlie them.

From this it follows that the break between the Permian and Trias of Devon is marked by the absence of the Lower Bunter of the Midlands, and the author quotes remarks of Mr. Ussher in support of his view that there is an unconformity at the base of the Pebble-bed.

In conclusion the author refers to the difficulties of ascertaining the exact age of the breccias, and notes that we cannot prove that the highest Carboniferous beds are present in Devonshire. He observes that there is no valid reason why the great breccia-sandstone series of Devon should not be the true equivalent of the Lower Rothliegendes both in time and position in the sequence, and that some portions of them may be even older than the Rothliegendes of some districts. He discusses the evidence furnished by the igneous rocks, and points out the abnormal position both for the British and German areas which these would occupy, if the breccias were of Triassic age.

III.—December 9, 1891.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Rocks mapped as Cambrian in Caernarvonshire." By the Rev. J. F. Blake, M.A., F.G.S.

In this paper the following is given as a definite succession in the Cambrian series:—1. Pale Slates; 2. Upper Purple Slates; 3. St. Ann's Grit; 4. Lower Purple Slates; 5. Rhiw-wn Grit; 6. Hard banded Pale Slates and Hälleflintas; 7. Bangor Conglomerate; 8. Hard banded Pale Slates and Hälleflintas; 9. Bangor Breccia; 10. Blue blanded laminated Grits; 11. Tairffynnon Conglomerate; 12. Blue banded laminated Grits; 13. Brithdir quartz-felsite Grit.

The general succession is argued to be the same in the isolated portion east and south of Bangor as in the main mass. The existence or otherwise of a base on the mainland is considered to depend on the age assigned to the Dinorwic felsite, and the presence of the summit-beds to depend on whether the Bronllwyd Grit (stated to belong to the overlying group) rests conformably or unconformably on the Cambrian rocks.

It is argued that the rocks to the west of the Llyn Padarn felsite belong to the lower part of the series and those to the east to the upper, and that the felsite is a volcanic complex belonging to the middle of the Cambrian period.

A post-Cambrian age is assigned to the conglomerates of Moel Tryfan and Llyn Padarn, thus causing the break at the base of the Silurian system to assume an increased importance.

2. "The Subterranean Denudation of the Glacial Drift, a probable Cause of submerged Peat and Forest-beds." By W. Shone, Esq., F.G.S.

A description is given of a section at Upton, Cheshire, where Boulder-clay rests upon the "mid-glacial sands." The Boulder-clay sinks to a lower level in the small valleys which are cut through into the sands; and the author supposes that this is due to the subterranean denudation of the sands, which would be greatest near the valleys, and become less at a distance from them. He considers such denudation is capable of producing submerged peat and forest-beds, and accounts for the splitting of peat-beds, as described by Mr. G. H. Morton, by a somewhat similar action, which he believes may have also operated in Carboniferous times, causing the splitting of coal-seams.

3. "High-Level Glacial Gravels, Gloppa, Cyrn-y-bwch, near Oswestry." By A. C. Nicholson, Esq. Communicated by W. Shone, Esq., F.G.S.

These gravels are found at Gloppa, and are situated at a height of from 900 to 1160 feet above sea-level, on the eastern slope of a ridge of Millstone Grit which forms the western border of the Cheshire and Shropshire plain.

The beds present the appearance of having been abruptly cut off on the north-eastern slope. The gravels are in places much contorted, and false-bedding is frequent. They contain numerous striated erratics. Amongst the boulders are Silurian grits and argillites, granites like those of Eskdale, Criffel, etc., Carboniferous rocks, Lias shale, and Chalk flints. The shells are often broken, rolled, and striated, but the bulk of them are in fairly good condition.

A list of the shells is given, including nine Arctic and Scandinavian forms not now living in British seas, nine northern types, also found in British seas, two southern types, and nearly fifty species of ordinary British forms. Comparative lists of the shells of Moel Tryfan and of those now living in Liverpool Bay are placed side by side with the list of shells from Gloppa.

CORRESPONDENCE.

GRANITE CUTTING CRETACEOUS ROCKS—A CORRECTION.

Sir,—In my Presidential Address to the Geological Society in 1885 (Proc. Geol. Soc. vol. xli. p. 75), I speak of having seen in the Alps "perfectly typical granite cutting Lower Cretaceous strata." The remark was founded on a note made in 1874. I am sorry to say that in these words there are two mistakes: the rock is of Tertiary not of Secondary age: the granite is not intrusive. As to the former matter I was misled by a small map, the only one which I then possessed; as to the latter I fell into a trap. The rock looked like a dyke of grey, not very coarse, granite cutting through a dark schistose rock. I was puzzled at not finding more distinct evidence of contact metamorphism; but this solitary slab-like mass in its general form so closely resembled a dyke, that I did not at that time suspect its true nature. Shortly after the above statement was published, a correspondent (I think Prof. Vélain) intimated to me that he believed I had made a mistake; my own doubts kept increasing; and last summer I again visited the spot, which is on the road from Sepey to Ormond Dessus.

The apparent dyke is one of those large erratics which occur not unfrequently in the *Flysch* of Switzerland, and others may be found at no great distance. How it was that I missed them on the former occasion, and thus failed to have suspicions awakened, I cannot understand, unless it be that changes have been made in the road. Possibly, as I had then worked but little at rocks, something else may have diverted my attention. Be that as it may, there can be no doubt that I made a mistake, and hope that there are not many such on my geological conscience. T. G. Bonney.

NOTE ON MR. HUTCHINGS'S PAPER ON SOME LAKE-DISTRICT ROCKS.

Sir,—As far as the evidence of the rock-sections goes, the rock from Thornthwaite Crag, described by Mr. W. M. Hutchings, may well be an altered trachyte (Geol. Mag. 1891, p. 543). But the analysis given would indicate a rock nearer andesite, like so many of the "oligoclase-trachytes" of the Auvergne. Considering how trachytes and andesites are associated in the field, and how the same lava-flow may contain varying proportions of porphyritic crystals in various parts, and may consequently yield alkalies in different proportions on analysis of different specimens, I think we must receive with caution the suggestion of an occult rather than a purely chemical cause for the differences between the crystallized constituents of the two types of rock. The analysis referred to by Mr. Hutchings as given in "Aids in Practical Geology" (p. 226 of that book) is that of a *Sodalite*-Trachyte of Ischia. Now I suspect that, had chlorine not been present, this rock would have developed albite and oligoclase in sufficient quantity to bring it at least to the verge of the andesite series. If we call the sodalite an "accessory" mineral, and deduct the soda required for its formation, we still have an excess of soda over potash in the rock; the monoclinic felspar present at Scarrupata, Ischia, is, no doubt, as is frequently the case, a soda-orthoclase. Such an analysis must not be regarded as typical of simple trachytes, but of the sodalite-trachytes, which, indeed, approach the phonolites. Judged by the bulk-analysis, then, the rock so clearly described by Mr. Hutchings has an affinity with the nepheline-trachytes (nepheline-phonolites) or the trachytic andesites. I fear any trace of original nepheline will have disappeared.

DUBLIN, *5th Dec.* 1891. GRENVILLE A. J. COLE.

CONCRETIONS IN MAGNESIAN LIMESTONE.

SIR,—If I am correct in thinking that Mr. Jukes-Browne considers that Carbonate of Lime was precipitated on the sea-floor during the formation of the Magnesian Limestone beds, I am inclined to agee with him; but this merely deals with the origin of beds of Magnesian Limestone, and does not account for the formation of the Concretions. If, however, he intended to suggest that the moisture contained in the deposit held the Carbonate of Lime in solution, I think the amount would be quite inadequate to account for the thick beds of concretions, and this method of origin would not explain the bedding planes which pass uninterruptedly through matrix and concretions alike. E. J. GARWOOD.

THE LATE P. HERBERT CARPENTER, M.A., D.Sc. (CAMB.) F.R.S., F.L.S.

The Editor has received the following note from Mr. FRANK SPRINGER, joint-author with Mr. Wachsmuth of numerous works and memoirs on the N. American Crinoidea. It is a high tribute of regret, regard and esteem from the United States for the loss of one whom we all deeply and sincerely mourn in England.—EDIT. GEOL. MAG.

DEAR Dr. WOODWARD,—It is with the most profound regret that I have learned the particulars of the death of our lamented friend Carpenter. It is difficult to aptly express the great loss it is to Wachsmuth and myself. Carpenter's rare scientific attainments and broad learning are known wherever Zoologists exist, but to us, who have been in constant correspondence with him for fourteen years, I think his untimely death brings a keener sorrow than to any outside of the circle of his intimate friends and relations. We had the greatest reason and opportunity to admire and appreciate him. Notwithstanding our many animated controversies in print upon disputed questions of Echinoderm morphology, and still more numerous and earnest battles in private correspondence, in which many a promising theory was warmly advocated, combated, and given up on both sides, our acquaintance long ago assumed the phase of cordial friendship and high personal regard. This was still more firmly cemented by my visit to him, while in England in 1887–8, and we feel his loss now as a personal bereavement. We were in the most confidential communication relative to our various works on the Crinoids, especially the one now in progress. We always interchanged advance sheets of our publications, and sometimes sent each other manuscript for examination and criticism. Carpenter was always the soul of honour in regard to information derived from these private communications, and was generous to the last degree in giving information from his great store of learning, whose value none could estimate higher than we. I should be very glad to know of any publications in England in recognition of his merits.

Hoping this will find you very well, believe me always, very sincerely yours,

Las Vegas, New Mexico, Frank Springer.
November 15th, 1891.

"ANNALS OF BRITISH GEOLOGY" FOR 1890.

Sir,—It is not my intention to make any comments on the criticisms which the compiler of the volume bearing the above title has thought fit to introduce into the notices of my papers, as those who have even the most superficial acquaintance with the subject therein treated will be able to appreciate the value of such criticisms. When, however, I am deliberately charged with making a blunder, which exists only in the mind of the compiler, it is time to say something. In noticing the fourth part of my "Catalogue of Fossil Reptilia and Amphibia," the compiler of the work in question goes out of his way to state that I have changed the names *Orthocorta* to *Orthopleurosaurus* without giving any reason for so doing. Now (without commenting on the circumstance that he had the reason for this change staring him in the face), if the compiler had taken the trouble to look at the notes at the bottom of the page, he would have seen after the reference to the name *Orthocorta*, the word "Hybrid." R. Lydekker.

UNCONFORMITIES BENEATH THE CAMBRIAN QUARTZITES IN SHROPSHIRE.

Sir,—In the Geological Magazine (1891), p. 485, is a paper by the Rev. J. F. Blake, in which he challenges some of my criticisms on his work in Shropshire. His chief assertions are the following:

(1). That at Pontsford Hill the Longmynd Rocks in contact with the Rhyolite are altered.

(2). That at Narnell's Rock there is an unconformity separating Cambrian from "Monian" rocks.

(3). That at Charlton Hill the conglomerates and grits are superficial, and are not a part of the Uriconian series.

Paper-contests in geology are rather unsatisfactory work, and I therefore propose to attempt a settlement of these disputed points, and any others that may be agreed upon, in the following manner. A competent geologist, to be selected by Mr. Blake and myself, to visit the ground in our company, and to publish his conclusions. The disputant who is convinced of his error to publish his recantation. The disputant against whom the referee decides in the majority of cases to pay the travelling expenses of the referee. I am aware that disputes cannot always be settled in this way; but the three sections I have named are so clear and simple, that a third party can hardly fail to come to an immediate decision, and we should select a person whose award would carry weight. If Mr. Blake refuses this challenge, I will offer to take any competent geologist to the sections, and to forfeit five gunieas to a hospital if I fail to convince him.

Ch. Callaway.

November 20th, 1891.

"CONCRETIONS" IN MAGNESIAN LIMESTONES.

Sir,—There is another possible method, besides those suggested by Messrs. Garwood and Jukes-Browne, by which the globular and pseudo-coralline and other forms so remarkable in the Magnesian Limestone of Durham may have originated—the mechanical; and this is slightly alluded to by Professor Sedgwick (page 92).

Many years ago a friend presented me with a considerable series of specimens obtained from the neighbourhood of Sunderland; their examination seemed to indicate that their forms were due to mechanical action, but it was difficult to imagine how the principle on which a school-boy's marbles, "alleys, tors and commoners," are formed from cubical fragments of stone, could have been applied by natural means; nor did a visit to the extensive quarries at Fulwell, north of Sunderland, assist in solving the problem. The promontory on which Tynemouth Castle stands may possibly help to afford a solution. The strata forming the base of the cliff consist of Coal-measure Sandstone, on which rests a bed composed of angular fragments derived from the same, and over this the Permian Limestone has been deposited. This Limestone is full of cavities resembling in appearance some examples of vesicular trap.

I would suggest that during the formation of the limestone, and whilst it was still in a more or less plastic state, gases evolved from the decomposition of vegetable matter forming beds of Coal made their way through the basement beds of limestone. Such vesicles as occur at Tynemouth might be expected to have been formed under these conditions, and it is quite possible that the globular forms of the so-called "concretions," which occur near Sunderland, may have originated from a similar cause, though under somewhat different circumstances, such as the amount of gas evolved; the amount to which the lately deposited limestone had consolidated, etc. Whatever was the cause of the fashioning of the globular masses, the same must have been the instrument by which the coral-like forms were shaped.

I much regret being so circumstanced that I could not conveniently carry out a series of experiments to determine the possibility of the globular forms being due to the cause suggested. The only rough attempt made was so far satisfactory that the passage of carbonic acid, generated beneath clay in a plastic state, resulted in the production of many small rounded forms.

Birkenhead, November, 1891. Charles Ricketts.

NEEDLESS ALTERATION OF ZOOLOGICAL NAMES.

SIR,—The want of a proper set of recognized canons to regulate the selection and retention of generic and specific names is becoming more and more urgent. We are constantly being told to abandon some well-known name because an older one has been found, or because it was previously given to some other organism; but such reasons are not sufficient by themselves. The author of a British Museum Catalogue has lately attempted to introduce the name of *Meretrix* instead of *Cytherea*, and that of *Lampusia* in place of *Triton*, two well-known genera of Mollusca; but the needlessness of the change has been exposed by writers in the pages of "Nature," and the author in question must be regarded as a culpable "disturber of the public peace" of mind. Such unnecessary interference with names engenders a feeling of opposition against any change of name, even when the change is desirable and well-founded. Cannot the Linnæan and Zoological Societies take common action with the International Geological Congress in establishing an International Committee on nomenclature, to which all new names and all proposed alterations of names might be submitted? The following letter appeared in "Nature" for November, and might be reproduced in every Biological and Geological Magazine.

EXETER, *November* 21. A. J. JUKES-BROWNE.

Meretrix, Lamarck, 1799, *versus Cytherea*, Lamarck, 1806.

In the notice of Mr. Newton's "List of Mollusca," in "Nature" of October 29 (vol. xliv. p. 610), I read as follows:—"Many old favourites have been thus relegated to obscurity, whilst fresh names, dug up from some forgotten corner, have, by the law of priority, taken their places. Thus, *Meretrix*, Lamarck, 1799, takes the place of his better-known *Cytherea* of 1806, the latter having been applied by Fabricius in 1805 to a dipterous insect."

The Dipteron *Cytherea obscura*, Fab., 1805, was described nine years later than *Mutio obscurus*, Latreille (1796), which is the same species. Meigen, in his principal work (1820), acknowledged the priority, and the insect has been called *Mutio* ever since. As the typical species is the same for both genera, there is no chance whatever for *Cytherea* to be resuscitated, and it may well remain as the name of the Mollusk. I most heartily agree with the opinion of the reviewer, that "it would be an immense gain if every name proposed to be altered had to pass through a regularly-constituted committee of investigation before it was accepted and allowed to pass current." In such a committee, besides *priority*, two other paramount scientific interests should be consulted, and they are—*continuity* and *authority*.

HEIDELBERG, *November* 1. C. R. OSTEN SACKEN.

OBITUARY.

◆

WILLIAM KINSEY DOVER, F.G.S.

WE have to record the death of an old friend, and brother geologist, Mr. William Kinsey Dover, F.G.S., who died at Low Nest, near Keswick, on the 27th of March, 1891, in his seventy-fifth year. After completing his education, Mr. Kinsey was for some years engaged in mercantile pursuits, but he left London in 1855, and entered the Cumberland Militia, in which he served as Ensign (1855), Lieutenant (1861), and Captain in 1865. On his retirement from the *Militia in 1868,* he devoted himself to Natural

History pursuits, and more lately to palæontology, paying especial attention to the fossils of the Skiddaw Slates, which he collected with great diligence and care, accumulating in time a very fine series of these rare Ordovician treasures. Mr. Dover was elected a Fellow of the Geological Society in 1880, and a member of the Geologists' Association in 1881, taking part in the Lake-District long-excursion of the latter body in that year, as one of its directors. In 1890 Mr. Dover presented his fine collection of Skiddaw Slate Fossils to the Woodwardian Museum, Cambridge, where it forms a most valuable contribution to our knowledge of the Geology and Fauna of the Lake-District rocks.

SIR ANDREW CROMBIE RAMSAY, KNT., LL.D., F.R.S., F.G.S.

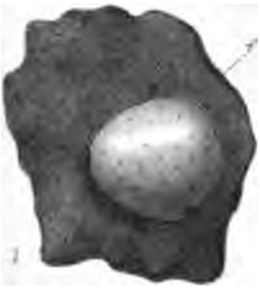
BORN 1814. DIED DECEMBER 9TH, 1891.

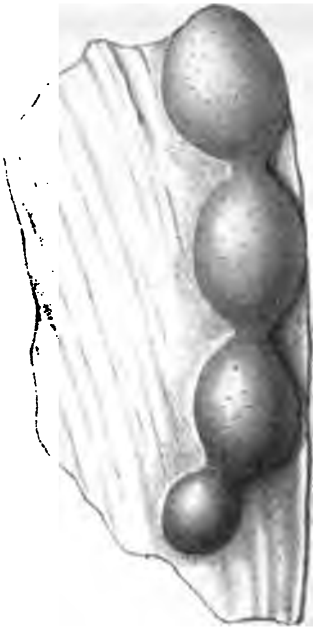
WE regret to record the death of Sir Andrew Ramsay, late Director-General of the Geological Survey, which occurred at his residence, Baumaris, Anglesey, Dec. 9th, 1891, in his 77th year.

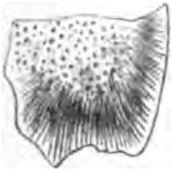
He was educated at Glasgow, and was appointed to the Geological Survey of England and Wales in 1841, and became Local Director in 1845. He was nominated Professor of Geology at University College in 1848, Lecturer on Geology at the Royal School of Mines in 1851, and was President of the Geological Society in 1862 and 1863. He was elected a F.R.S. in 1849, and Knight of the Order of St. Maurice and St. Lazarus in 1862, and was elected an honorary LL.D. of Edinburgh in 1866. He received the Wollaston Gold Medal from the Geological Sociey in 1871. On the death of Sir Roderick I. Murchison, Bart., he was made Director-General of the Geological Survey of the United Kingdom, and of the Museum of Practical Geology in 1872. On his retirement from these offices in 1881, he received the honour of Knighthood. He presided over the meeting of the British Association at Swansea in August, 1880. He was an Associate of many foreign societies. Sir Andrew Ramsay is author of "The Geology of Arran," "Geology of North Wales," 1858, 2nd edition 1881; "Old Glaciers of North Wales and Switzerland," 1860; the "Physical Geology of Great Britain," 1878; and of very many memoirs, chiefly on theoretical geology.

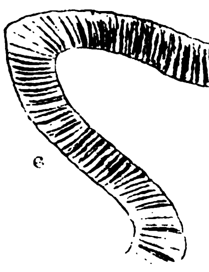
His life and portrait appeared in the GEOLOGICAL MAGAZINE for 1882, Decade II. Vol. IX. pp. 289–293.

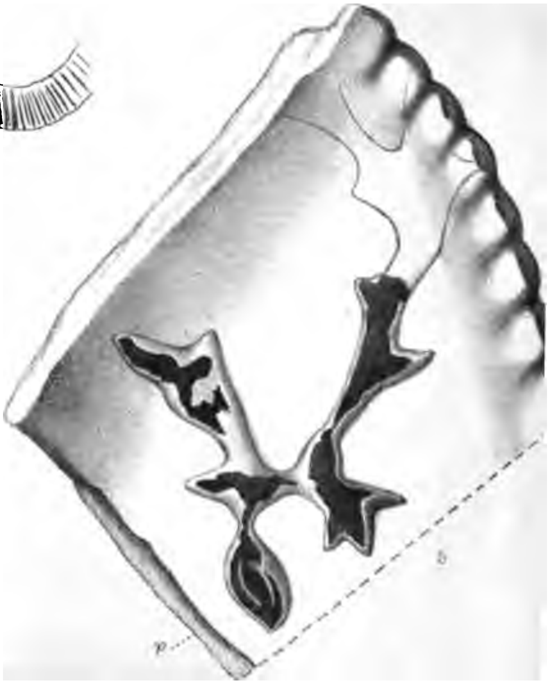
DR. FERDINAND VON ROEMER, Professor of Geology and Palæontology in the University of Breslau, whose Jubilee as Professor it was intended to celebrate on 10th May, 1892, died at Breslau, on the 14th December, 1891, in his seventy-fourth year. Dr. Roemer was elected a Foreign Member of the Geological Society in 1859, and was awarded the Murchison Medal in 1885. We shall give a notice of this distinguished Geologist in the February Number.—EDIT. GEOL. MAG.

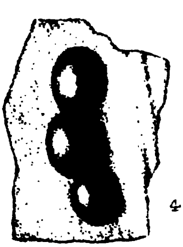

1


3


2


6


5


4

G. M. Woodward lith. West, Newm

New Gault Foraminifera.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. IX.

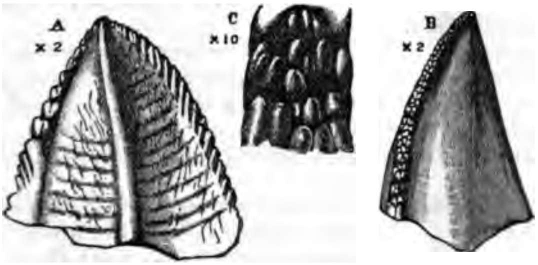
No. II.—FEBRUARY, 1892.

ORIGINAL ARTICLES.

I.—Note on an Iguanodont Tooth from the Lower Chalk ("Totternhoe Stone"), near Hitchin.

By E. T. Newton, F.G.S.

THROUGH the generosity of Mr. W. Hill, the Museum of Practical Geology possesses a tooth found in the "Totternhoe Stone" in the neighbourhood of Hitchin, which is of especial interest inasmuch as it is undoubtedly closely related to *Iguanodon*, and is of later date than any British Dinosaurian remains hitherto recorded; the *Acanthopholis horridus* of Prof. Huxley,[1] from the Chalk Marl, and the *Trachodon* (*Hadrosaurus*) *Cantabrigensis*, of Mr. Lydekker,[2] from the "Cambridge Greensand," being, up to the present time, the most recent of known British Dinosaurs. Remains of allied forms, however, have been found at a higher horizon of the Chalk of Maestricht, and have been described by Prof. Seeley,[3] and M. L. Dollo.[4]



Explanation of Figures.

A. Iguanodont tooth from the "Totternhoe Stone" near Hitchin. Enamelled surface. Enlarged twice nat. size. B. Same tooth, seen in profile.
C. Portion of crenulated edge. Enlarged ten times nat. size.

The specimen to which attention is now directed is the upper part of the crown of an unworn tooth, in an admirable state of preservation; its lower part was evidently broken away before it was imbedded in the Chalk, and the sharpness of the fractured edges, as well as of the denticulations, shows that it has undergone no subsequent attrition. The greatest length of the portion preserved is about 0·6 inch, and its width from before backwards 0·5 inch, whilst the greatest thickness, at the fractured end, is about 0·4 inch. The enamelled surface is somewhat pointed at the apex, and has a single crest, extending from top to bottom, which divides this surface into two unequal areas. The anterior and posterior margins are ornamented with strong serrations, from which grooves extend, almost vertically, some distance on to the enamelled surface. When viewed from before, the crown is wedge-like, and the serrations of the edge, when seen with a lens, are found not to be simple, but each of them is itself denticulated, giving a mammillated appearance to the somewhat thickened edge. The enamel is slightly roughened by small vermiform rugæ.

---

[1] Geol. Mag. Vol. IV. 1867, p. 65.
[2] Q.J.G.S. vol. xliv. p. 47.
[3] Q.J.G. S. vol. xxxix. p. 246.
[4] Bull. Mus. Roy. Hist. Nat. Belg. vol. ii. p. 205, 1883.

The close resemblance between this tooth, so far as preserved, and some of those figured by Sir R. Owen[1] as *Iguanodon Mantelli*, would lead to the inference that it belonged to the same species were it not that one of these (figs. 15, 16) having only a single ridge on the enamelled surface, has more recently been referred by Prof. Seeley[2] and Mr. Lydekker[3] to *Trachodon* (*Hadrosaurus*), and as our specimen has only a single ridge, it would seem, at first sight, that it also should be referred to *Trachodon*. However, Sir R. Owen's figures 10 and 17 have only small secondary ridges of the enamel, and these do not extend far from the base of the tooth, our specimen therefore might well be a portion of such a tooth with the small ridges broken away. Besides this, another tooth with only a single enamel ridge, which is from the Wealden, is called *Iguanodon* by Sir R. Owen,[4] and no one seems to have questioned the correctness of this determination.

Then, again, with regard to the serrations, these are coarser than in the figures of *Trachodon*,[5] and the grooves extend from them some distance over the enamelled surface, a character seemingly wanting in *Trachodon*. The mammillations of the serrations find their counterpart in both *Iguanodon Mantelli* and *Trachodon* (*Hadrosaurus*) *Foulkei*.

The Dinosaurian remains from the Maestricht Chalk described by Prof. Seeley and M. L. Dollo include certain bones which are said to have affinities with *Iguanodon* and *Hadrosaurus*; they have been named *Orthomerus Dolloi*. It is possible that the tooth from the "Totternhoe Stone" may prove to belong to the last-named genus; but as there is no evidence at present of the teeth of *Orthomerus*, it would scarcely be wise to refer our specimen to it; on the other hand, it is quite certain, that in whatever genus this tooth may eventually have to be placed, it is very closely related to *Iguanodon*, and with this it will provisionally be included, and named specifically after its donor *Iguanodon Hillii*.

---

[1] Pal. Soc. Cret. Rept. suppl. ii. pl. vii. figs 10, 15, 16, 17.

[2] Q.J.G.S. vol. xxxv. p. 591, 1879.

[3] Q.J.G.S. vol. xliv. p. 47, 1888.

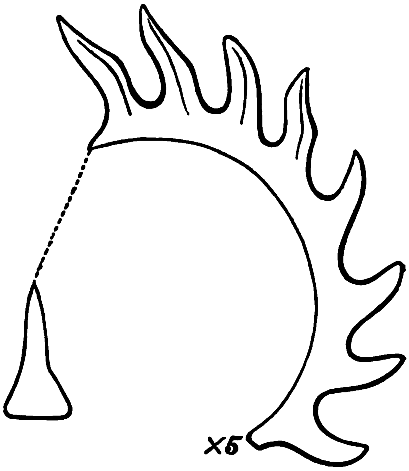
[4] Pal. Soc. Rept. Wealden, pt. ii. pl. xviii. fig. 6, 1855.

[5] Leidy, Smithsonian Contributions, vol. xiv. 1865.

II.—NOTE ON A NEW SPECIES OF *ONYCHODUS* FROM THE LOWER OLD RED SANDSTONE OF FORFAR.

By E. T. NEWTON, F.G.S.

THE occurrence in the Ledbury "Passage-beds" of a united series of teeth referable to the American type of fossil fishes named by Prof. Newberry *Onychodus*, was made known by Mr. A. Smith Woodward in the GEOLOGICAL MAGAZINE for November, 1888; and in the British Museum Catalogue in 1891. Since then I have met with another example of the genus among the stores of the Geological Survey, which, as it seems to be quite distinct from the Herefordshire species, and is from a distant locality, deserves to be placed on record.



Onychodus scoticus, n. sp., from the Old Red Sandstone of Forfar. Presented to the Museum of Practical Geology by James Powrie, Esq., F.G.S., of Reswallie.

The specimen consists of a series of teeth from the Lower Old Red Sandstone of Turin Hill (?), Forfar, and has been presented to the Museum of Practical Geology by Mr. James Powrie, of Reswallie, who has done so much to extend our knowledge of the fauna of these rocks. This series of teeth, is preserved in a shaly layer covering a small block of hard grey sandstone; and the shale having been split open, the fossil itself has been broken through from end to end, one half being retained in each piece of shale; portions of some of the teeth, however, have fallen out. There are eight teeth placed one before another in a single row, with their bases coössified so as to form a rigid semicircular base, which measures about 9 mm. in a straight line from end to end. Two of the teeth seem to have been quite perfect when imbedded in the shale; but the others are more or less worn down and rounded. The longest and most perfect tooth is about 4 mm. in length; and the shortest nearly 3 mm. The basal *portion, so* far as one can judge from a wax impression, is about 2 mm. wide. Each unworn tooth is strongly curved, or rather crooked, with an acute somewhat recurved point. The concavity of each tooth is directed towards the end where they are least worn. The cavities, left by the teeth which have fallen out, show that these teeth were provided with a very distinct ridge on each side, and they appear to have been flattened from before backwards.

An examination of the broken surfaces with a lens reveals a very vascular condition of the base, and large vessels pass from this into each tooth. No division can be traced between the bases of the teeth, which are evidently firmly united to each other.

Compared with *Onychodus anglicus* and *O. arcticus*, the present specimen differs in the more uniform size of its teeth, the longest of which is not half the length of the most perfect tooth in the former species, from which it also differs in the greater curve, and non-involution of the base; and further, its teeth have distinct lateral ridges and no central cavity.

The uniform size of the teeth in the Forfar specimen agrees better with the American forms, but they are much smaller than in any one of the three species described by Prof. Newberry, and are of a different shape. In *O. Ortoni* the teeth are said to be sunk in the base "as posts are planted in the ground."

British examples of this genus are so rare that even such fragments as that above described may well receive specific distinction, and I propose to name it *Onychodus scoticus*.

The following are the species of *Onychodus* now known :—

O. sigmoides, Newberry. Corniferous Limestone (Lower Devonian), Ohio. Monog. U. S. Geol. Surv. vol. xvi. p. 56, 1889.

O. Hopkinsi, Newberry. Chemung Group (Upper Devonian), Delaware Co., New York. *Ibid.* p. 99.

O. Ortoni, Newberry. Huron Shale (Upper Devonian), Franklin Co., Ohio. *Ibid.* p. 71.

O. anglicus, Smith Woodward. Lower Old Red Sandstone Passage Bed, Ledbury, Herefordshire. GEOL. MAG. Vol. V. 1888, p. 500, and Cat. Foss. Fishes, Brit. Mus. part 1, p. 393, 1891.

O. arcticus, Smith Woodward. Lower Devonian, Spitzbergen. GEOL. MAG. Vol. VI. 1889, p. 499; and Ann. Mag. Nat. Hist. vol. viii. 1891, p. 1.

O. scoticus, Newton. Old Red Sandstone, Forfar.

III.—SOME NEW FORMS OF HYALINE FORAMINIFERA FROM THE GAULT.

By FREDERICK CHAPMAN.

(PLATE II.)

IN the course of investigations amongst the Microzoa from the Gault of Copt Point, Folkestone, some Foraminifera came under my notice, which are hyaline representatives of the usually arenaceous type *Webbina*. These forms are remarkably similar in external appearance to those of the arenaceous group, but microscopical examination of the test under a high power reveals the finely tubulated structure characteristic of the hyaline type.

It must, however, be borne in mind that the isomorphous genera in the three groups of the Foraminifera based upon shell-structure are of classificatory rather than biological value; it being most probable that the same organism may possess the ability to form the structure of its external covering according to the conditions under which the Rhizopod exists.

Dr. Sollas has described[1] two forms of Hyaline Foraminifera from the Cambridge Greensand under the generic term *Webbina*, which presents the same finely perforated structure as the Gault specimens, and he has proposed to reserve the generic term *Webbina* for the type he describes possessing the perforate character. The structure of the shell wall of these perforate varieties, as Dr. Sollas points out, shows the type to be closely related to the Rotaline Foraminifera: and since there is present a shelly flange which may possibly be equivalent to the keel-like edge of some *Pulvinulinæ*, I would therefore suggest that the perforate varieties of *Webbina* might form a separate genus, which would find a place between *Rupertia* and *Pulvinulina*.

Another somewhat remarkable form found is interesting on account of the prominence which it gives to the fact of the great variability of the Foraminifera. This is an adherent and ramifying variety of *Polymorphina*. In general appearance it somewhat resembles the form *Sagenella* of Dr. Brady, especially in the shape of the terminations with their simple apertures. In a few specimens, however, the portion of the test, which is rounded and inflated, and is much smaller than the ramified portion, shows a decidedly chambered structure, identical with that of *Polymorphina*; and this is confirmed by one individual of which the test was broken, showing the chambered portion. The cervicorn and fistulose varieties of *Polymorphina* are very fully discussed in Messrs. Parker, Jones, and Brady's paper on the genus *Polymorphina*;[2] under the name of *Polymorphina Orbignii*, Zborzewski, sp.

Vitriwebbina, gen. nov. Pl. II.

General characters.—Test opaque to translucent, of a whitish or pale-brown colour. Shell-wall very finely perforated. Consisting of a single hemispherical or pyriform chamber, or of a graduated series disposed usually in a curved line, and adherent upon some foreign substance. The chambers are connected by stolon tubes, very distinctly seen on the under surfaces of the specimens which have become detached. The surface of the shell may be smooth, pitted, or, as in Dr. Sollas's specimen, tuberculate.

Vitriwebbina Sollasi, sp. nov. Pl. II. Figs. 1–3.

This form consists usually of one, but sometimes of even four pyriform chambers, always adherent, in many cases to rolled fragments of phosphatic nodules. The test is usually white, though sometimes pale-brown and opaque, and the shell-wall is finely tubulated, with the exception of a thin encircling flange of shell material as it were completing the fusion of the shell to its attachment. This peculiar flange of shell substance is present in Dr.

---

[1] Geol. Mag. Dec. II. Vol. IV. 1877, p. 102–105, Pl. VI.

[2] Trans. Linn. Soc. vol. xxvii. 1870 (1871), pl. xlii. figs. 38 *a*—*o*, pp. 244–248.

Sollas's specimens, but turned *inwards* on the foreign body. This variety occurs in Price's Zones I. III. V. VII. and XI. at 20 feet from the top of the Gault, at Copt Point. I have also since found it in the Gault at Battlebridge, Merstham, Surrey. I have associated the name of Dr. W. J. Sollas with this form, who first described the perforate type.

Vitriwebbina lævis, Sollas, sp. Pl. II. Fig. 4.

This form has already been recorded by Dr. Sollas, and is mentioned here in passing as occurring in the Gault beds of Folkestone in Zones IV. VII. and XI. at 50 feet from the top.

Polymorphina Orbignii, Zbor. sp., *cervicornis* var. nov. Figs. 5 and 6.

The test, which is generally found attached to shell fragments, such as *Nucula*, commences with a polymorphine arrangement of chambers, which proceeds to take on a wild flattened fistulose growth, sometimes six times the length of the initial series of chambers. The apertures are simple orifices at the terminations of the branchlets. An example occurs in which the branching growth has just commenced. This variety is found in Zones III. and VII. of the Gault at Copt Point.

In concluding these notes, I wish to acknowledge the kind advice I have received from Prof. T. Rupert Jones, F.R.S., and also the valuable assistance of my friend Mr. C. D. Sherborn, F.G.S.

EXPLANATION OF PLATE II.

Fig. 1.—*Vitriwebbina Sollasi*, sp. nov., showing thin encircling flange *f* (× 60).
,, 2.—*V. Sollasi*, fragment of test showing tubulate structure (× 360).
,, 3.—A specimen of ditto with four chambers (× 60).
,, 4.—*V. lævis*, Sollas, sp. (× 40).
,, 5.—*Polymorphina Orbignii*, Zbor. sp., var. *cervicornis*, attached to a fragment of shell of *Nucula*. The lines indicating the later growth are slight grooves in the shell to which the Foraminifer was attached, as if the foreign body were partially dissolved along the lines of attachment; *p.* represents the polymorphine series of chambers. The whole of the shell contains an infilling of pyrites (× 30).
,, 6.—The apex of one of the branches of *P. Orbignii*, var. *cervicornis*, showing the finely tubulated shell-wall.

IV.—The Absence of Glacial Phenomena in large Parts of Western Asia and Eastern Europe, etc.

By Henry H. Howorth, M.P., F.G.S., etc.

In some papers which you have done me the favour to print in the Geological Magazine, I have endeavoured to apply a new touchstone to test the age of high mountain chains and of land of high elevation, namely, the presence or absence of distinct and prominent traces of former glaciation, and I have argued that where such traces are not forthcoming in a very unmistakable manner, we are justified in concluding that these highlands have been elevated since the so-called Glacial Period. I have endeavoured to apply the touchstone in question to the Ural and Altai Mountains, to the Thian Shan and Himalaya ranges in Asia, and to the great Cordillera which binds together the two continents forming the New

World. I wish to make my survey more complete by an examination of an interesting area comprising Eastern Europe and South Western Asia.

Before addressing myself directly to this issue, however, I feel under an obligation to reply to the criticisms of Mr. Blanford. They appeared when I was far away from England, or they should have had an earlier notice.

In one of my papers I quoted the testimony of four geologists of wide-spread fame and great experience, keen and patient observers. whose works are geological classics, who had visited and explored with great pains the Urals, the Altai Mountains and the Thian Shan range, namely, Humboldt, Tchihatchef, Von Cotta, and Severtsof. All these observers had examined geological phenomena in many latitudes and were familiar with glacial marks, and all of them failed to find the footmark of the Glacial Period in the ranges in question, although they looked for them. This is assuredly a strong case. How does Mr. Blanford dispose of it? He says he can attach no value to the evidence brought forward, because (mark the phrase) "I myself was at one time led away by it." To measure the capacity of some of the greatest geologists of modern times for distinguishing what I venture to think are among the most obvious of phenomena, by the fact that the critic, like every other good man, has once made a mistake, seems to me to involve an appeal to other than scientific reasoning.

Let me add that, as Mr. Seebohm has reminded me, Père David, who spent many months at Moupin, on the frontier of China and Tibet, at the foot of a mountain as high as Mont Blanc, failed to find traces of old glacial action there, a result which was, I believe, also reached by Richthofen in other parts of China.

This is assuredly a very important addition to the strong chain of witnesses I have previously quoted in your pages in references to the great congeries of mountains in Eastern Asia.

Turning to the Himalayas, Mr. Blanford does not dispute the fact that in Peninsular India and in the great plains of the Indus and the Ganges, the real Hindostan, no true glacial phenomena are forthcoming. He urges, however, that they do occur high up in the Himalayas on a scale quite incommensurate with my arguments. I have not visited the Himalayas myself, but I did quote two experienced observers, Mr. Campbell and General McMahon, whose testimony is decidedly at issue with Mr. Blanford, and who had visited the country. It is true that some of Mr. Campbell's *theories* are fanciful enough; but I never met any one who disputed his keen eye for, and his extraordinary knowledge of, glacial facts in all parts of the world. Apart from these explorers, however, I appealed to a witness who is unbiassed by our discussions, who has no views whatever as to the glacial theory. I mean the Sun. Mr. Blanford seems to have a contempt for photographs. I am bound to say I differ from him *toto cœlo*; and I have examined glacial phenomena over as much ground as most people.

In regard to the main and most satisfactory evidence of glaciation, more satisfactory than either boulders or scratched stones or moraines, namely, the rounded and curved outlines always present when a glacier has polished a valley, I know of no testimony so excellent as that of photographs, for by their help we can rid ourselves at once of the personal equation of the observer whether he have ice or water on the brain. I appealed to photographs—many of which I had seen—and to that appeal I adhere. I contend they are a complete justification of my views.

I never argued that when you get up into the higher valleys of the Himalayas there is no evidence of the former presence of glaciers. I emphatically stated that there is, as Hooker and others showed long ago; but I did and do contend that these traces of former glaciers are infinitesimal compared with what they ought to be if the Himalayas had existed when the great Rhone glacier was depositing its famous loads far and wide.

I do not quite understand the reference to a difference of latitude which Mr. Blanford says I have overlooked. What has latitude to do with the question? Assuredly the Urals, which rise in places to a height of 1525 metres, and which are covered with snow for eight months in the year, the Altai Mountains, which are higher, and the Northern Rockies are all in latitudes which, if that had anything to do with the question, would have placed them at least on the same level as the Alps, the Pyrenees, and the Scotch Mountains, which have such abundant traces of glacial action upon them. It is not latitude that has to do with the question, but an abundant supply of moisture, and a sufficiently powerful source of cold. With these two conditions there will be abundant snow and ice, whatever the latitude.

When I spoke of a great Asiatic Mediterranean having existed during the Glacial period, it was not, as Mr. Blanford seems to suppose, to invoke an army of icebergs as having existed there, which I altogether disbelieve in; but to point out that this reservoir of water close at hand would supply the very moisture necessary for a tremendous glaciation of the Asiatic mountain chains, and notably of the Altai, if those mountain chains had then existed.

Granting this supply of moisture, granting the capacity of these high ranges as excellent condensers, we have in the wide area they cover the necessary elements for a huge development of ice. If there is no evidence of this ice having existed, then I would urge again that it goes a long way to prove that the great mountains did not exist either at the time in question.

That the glaciers have been bigger no one disputes, but I hold with Godwin-Austen that this was comparatively recently. On this subject he wrote as follows in the Geological Journal many years ago:—

"I have often been struck by the indications of considerable amounts of change of temperature *within what may be called our own times*. The proofs of this are to be found in many parts of the great Himalayan chain. These consist in the numerous terminal moraines which in so many places abut on the larger rivers, down to which point glaciers must have once descended, and which in some cases must have rivalled in length the present ones of the Mustakh range. . . . . . Among the proofs that *there has been a change of temperature of recent date* are the following. Many passes which were used even in the time of Rajah Ahmed Shah of Skardo, are now closed. The road to Yarkand over the Baltoro glacier, which before his time was known as the Mustakh, has by the increase of the ice near the pass become quite impracticable. The men of the Braldoh Valley were accordingly ordered to search for another route, which they found in the present pass, at the head of the Punmah glacier above Chiring. Again, the Jussespo La can now be crossed only on foot; whereas in former times ponies could be taken over it. The pass at the head of the Hoh Loombah is now never used, though there is a tradition that it was once a pass; no one, however, of the present generation that I could hear of had ever crossed it. Certain large glaciers have advanced, such as that at Arundu, of which the old men assured me that in their young days the terminal cliff was 1½ miles distant from the village. Mr. Vigne says, 'it was a considerable distance,' it is now only 400 yards. A like increase has taken place at Punmah, where, within the last six years, the road has been completely covered by the ice and moraine, and where Mahomed, my guide, told me the old camping ground was, now lies a quarter of a mile under the ice; the overthrown trees and bushes plainly testified to the recent advance which this mass has made; this evidence was equally well seen along the side of the Arundu glacier. Even so lately as twelve years since, the people of Shigar were enabled to get two crops off their fields; thus the first crop (barley) was followed as soon as cut by a second (kungŭni), which ripened by the end of autumn. Since that time it will not come to maturity, so that after the barley the fields now lie fallow, and the kungŭni has now to be sown earlier in the season" (Journ. Roy. Geog. Soc. vol. xxxiv. p. 51.)

In regard to the shrinkage of the glaciers, evidence is not of the same kind, for the good reason that during recent years the stage has been one of growth, but the same author's descriptions point to the traces of former extension as being comparatively recent. Thus he says of the Punmah glacier: "This glacier has in some past years been upwards of a 100 feet thicker than it now is, as shown by its lateral moraines, and the grooved and scratched rocks on either side" (*id.* 30). Again, speaking of the glacier of Biafo, he says: "The present thickness of the ice is a point not easily determined; but, judging from striæ in the sides of ravines from which glaciers have retired, from 300 to 400 feet, is not an exaggerated allowance for what they once have been" (*id.* 50). Speaking of Basho he says: "Glacier action of former times was here very apparent in the great masses of angular rocks above the village. The enormous collection of angular fragments in the terminal moraine of a large glacier, the remains of which are to be sought higher up, and where now it is only 4 or 5 miles long, with broad feeders from the mountains on the west side" (*id.* 54). *This will* suffice from Godwin-Austen.

I might have quoted another witness. In a note to an admir and most interesting work on Eastern Persia well known to and to Mr. Blanford, and on page 470, I find the following: " brother, Mr. H. F. Blanford, has suggested to me that the gre humidity of Persia and the neighbouring countries in former ti may have partly accounted for the former great extension of glac in the North-West Himalayas. If the west wind so prevalent North-Western India were moist, instead of being hot and dr it now is, there would be certainly a great increase in the deposi of snow on the Western Himalayan ranges." Nay, I might h as I have before, quoted Mr. Blanford against himself; for, i paper on Persian superficial deposits, he argues that the drying of Central Asia is connected with the elevation of the Steppe re of Central Asia (J.R.G.S. vol. xxix. p. 500).

In this I completely agree. The desiccation of Central Asia is g on at this moment. We have a great deal of evidence about shrinkage of its lakes and the disappearance of its streams in hist times. With this desiccation I hold the shrinkage of the As glaciers has also proceeded; and we need not, especially if we champions of Uniformity, go back beyond a reasonable date in o to find an ample and sufficient cause for the increased length of Himalayan glaciers in recent times.

Another point in Mr. Blanford's criticism I do not quite fol I understand him to say that because the Wild Ass and the Ante can live now at great heights, the Rhinoceros could do the s The Rhinoceros is essentially a tree-feeding and shrub-feeding ani and does not graze on short grass; and we know the kind of t which the *Rhinoceros antiquitatis* fed upon. To postulate that Rhinoceros could live where the Antelope lives is to me, saying that the Zebra could live where the Wild Ass of Mon lives; that Cape Buffalo could live where the Bactrian C lives; and that the Bison could exist where the Musk Sheep thri I do not understand the argument: nor do I understand why existence of a zoological sub-province in China, which has established by a chain of observers from Brian Hodgson to David, precludes the notion, otherwise so strongly supported, the Highlands of Eastern Asia are a recent feature in phy geography.

This, I think, completes my reply to Mr. Blanford; and I now pass on. My argument was not meant to be restricted to great masses of mountains in Eastern Asia. These masse mountain are closely united in their physical history with highlands stretching from the Hinduh Koh westward thr Persia; and it is a remarkable fact that there also we ha singular absence of erratic phenomena and of traces of a so-c Glacial period.

On this subject Mr. W. T. Blanford says: "In Persia the cou although greatly elevated above the sea-level, is covered with d but I found no signs of striation on the pebbles," nor had he able to detect glacial markings on extensive plateaux more

6000 feet above the sea, with peaks rising to 12,000 feet and even more (Q.J.G.S. vol. xxx. p. 478). Elsewhere he says: "Of glacial action in Persia there is, perhaps, a trace in the thick gravel found locally, as near Karman, on ranges of considerable height. *At the same time no clear evidence of ice action could be detected. In the Elburz Mountains, which are in about 36° latitude, neither Dr. Filippi nor I could find any evidence of former glacial action.* It is true that neither of us had much opportunity for exploring; but it is remarkable that Abich should have called attention to the same absence of glaciation in the Caucasus" (Blanford's Eastern Persia, p. 470).

Dr. Filippi, whose memoir is before me, speaks in the same terms. He very naturally asks where the great mass of water can have come from to spread the gravel which occupies so much of the surface of Persia, *to explain which he says we must not have recourse to a glacial epoch of which there is no trace in the Elburz Mountains,* "di cui non vha nelle montagne dell' Elburz alcuna traccia" (Atte della Soc. It. de Sci. Nat. vol. vii. p. 283). The same writer calls attention to another fact which I would quote here, and which corresponds with what I have said of the Ural Mountains and the American Cordillera, namely, that these great masses of high land form no zoological frontier, and are therefore presumably of very recent origin. "A great continuous barrier," he says, "like this, ought, like the other principal mountain chains of the world, to form a frontier separating two sensibly distinct faunas, but this is not the case. There is a greater difference between the fauna on the two sides of the Alps, and on the east and west of Europe than on the two sides of the Elburz" (*id.* 279–280). He further urges that the fauna of the high ground in Western Persia is essentially that of the Caspian depression and of the Turanian Steppes, which seems to me to also point to these highlands having been elevated very recently.

No doubt Mr. Palgrave, who by the way was not a geologist, did profess to find considerable traces of old glacial action in the neighbourhood of Erzerum, as others have professed to find them in the Caucasus. In answer I would refer to the observations of a most acute and experienced geologist, namely Abich.

In an elaborate memoir by him on the geology of the Caucasus and the mountains of Armenia and North Persia, published in the 7th volume of the Memoirs of St. Petersburg Academy, he says: "The distribution of erratic blocks, together with the associated phenomena of the grinding and polishing of rocks, is foreign to the Caucasus. Nevertheless, large blocks of stone and masses of rock of large dimensions, like erratic blocks in many respects occur in some of the valleys, especially those of the Terek; often too they have travelled some distance. But the transport of these blocks has nothing in common with the true diluvial phenomena of the period of erratic blocks of the European mountains, but is assignable merely to alluvial action which still operates, though in a diminished manner." He describes how, through the conformation of the valleys, especially in such places as the narrow pass of Dariel, great barriers of debris are found which dam back lakes 200 or 300 feet deep, and when these burst their bounds, great masses of stone are carried along the Terek Valley as far as Wladikawkas. Abich mentions how the great earthquake in 1840 which destroyed the village of Argnri in the district of Ararat, was followed by a great rush of waters which bore along great masses of rock much larger than those now to be seen in the Terek Valley. Similarly, he says, great blocks of 250 to 300 feet in circumference have been carried from the district of Ararat for a distance of seven versts over an inconsiderable slope.

Abich goes on at some length to show that the moraines and other glacial phenomena of the Caucasus are very local and confined to the upper valleys, and do not protrude out into the open country in the way they do in the West of Europe, and that they are the obvious handiwork of the existing glaciers, and do not point to a glacial period. I prefer to quote his conclusion in his own words. "So läge denn in diesen Moränen des Gyoal Don, die einzigen von so bestimmten Charakter und solche Grösse mit in Kaukasus bekannt gewordenen, ein annäherndes Maass für das Maximum des Gletscherwerkungen von, wie sie seit dem Begunt und dem Verlaufe der alluvialzeit bis zur Gegenwart, hier durch lokale mit der Entstehung des Kasbek zusammenhängende physikalische Configuration der Kamm region bedingt worden, niemals aber das Privilegium einer besonderen etwa eine allgemeine erhöhete Gletscherbildung bedingenden, oder auch nur begünstigenden Epoche für das Kaukasus gewesen sein können" (Mems. St. Pet. Acad. vol. vii. pp. 519–523).

The same conclusions were arrived at by Mr. J. F. Campbell, whose wonderful appreciation of glacial phenomena is specially apostrophized by Professor Judd. As he neared the Kaspes peak, he says, "We drove over undulating plains of clay and passed a lot of large stones; but I could find no scratches. In the evening I walked to the right bank of the river and found a great ridge of clay which I took for a moraine; but even here I could find no scratched stones. I believe it to be part of a delta, I sketched and inspected brick-pits, and reluctantly gave up my Caucasian glacial hypothesis. . . . . We drove up a beautiful gorge with well-marked terraces of rolled stones at the mouth of it, and with many very large stones scattered about; but I saw nothing glacial in the gorge." Speaking of the route between Kazbeg and Tiflis, he says: "The outlines of the mountains are due to weathering. Except large stones I could find no trace of glacial action in the whole journey of 202 versts (133½ miles) . . . . After a careful search in the valley lower down than Zalkan all the large stones that I could find were smooth water-worn pebbles taken out of the clay and out of great beds of rolled stones which there make large hills. . . . . If ever glaciers worked in the range, their traces have been almost entirely obliterated. . . . . I could find no signs of glaciers even on the remnants of the old surface through which the water has dug a couple of thousand feet or more." Speaking of the only lake in Daghestan, the water of which is dammed by a dam of angular gravel, which may be a terminal moraine, he says: "I could find no glaciated rocks anywhere about the lake. The moraine is the only mark of glaciation that I could identify in the whole range while travelling from end to end. . . . . From lat. 40° to 45° N. long. 50° to 35° E. I could not find one rounded hill or hollow, one scratched rock or stone, one perched block, one lake-basin, certainly due to glacial erosion, a glacier, or the trace of one. The highest hills are jagged sierras, the lower hills pyramidal or scarped, the valleys of all sizes are shaped liked a V" (Q.J.G.S. vol. xxx. pp. 460–466).

Let us now turn to another mountain-range, namely, that of the Lebanon in Northern Syria. Here Sir J. Hooker many years ago (Nat. Hist. Rev. Journ. 1862, p. 11) described the Cedars as growing on very considerable moraines, and this fact has been quoted in almost every manual of geology as evidencing the former glaciation of the Lebanon. The facts are, however, very doubtful indeed, and it is clear that in view of recent explorations they will have to be revised.

In a paper by M. Louis Lartet published in the 22nd volume of the Bulletin of the French Geological Society, embodying his researches extending over several months in Syria and Arabia, he refers to these supposed moraines, and urges that they are not really moraines and do not belong to the so-called Ice age at all, in the first place because he had never seen any scratched pebbles or other traces of glacial action in the midst of these deposits, and secondly, because they contain no basaltic pebbles or boulders showing that they must be older than the outbreak of basalt, etc., which have left such marks on the country, and he identifies them with the calcareous conglomerates long ago described by Botta (Mém. de la Soc. géol. de France, 158) to similar beds described by Russeger in the Orontes Valley, also composed of conglomerates cemented together by calcareous matter and which he treated as diluvian. Damascus is built on a similar bed, and it also occurs at the foot of Anti Libanus and on the eastern shores of the Lake of Tiberias (*op. cit.* p. 458).

There is a similar difficulty about the supposed glacial beds in the Atlas range. Ch. Grad, who explored the range, found no traces of ice-action there (see Zeitschrift der öst Gesellschaft für Meteorologie, 1873, p. 32).

If we turn to Asia Minor, we shall naturally turn for geological information to the detailed and masterly work by Tchihatchef. He explored the peninsula with great pains, and he says emphatically that all the phenomena of the Glacial epoch are absent from Asia Minor, and he adds that this is very curious, since the climate of Asia Minor is even under present conditions considerably influenced by the cold of Russia (Tchihatchef, Asia Mineure, 4th part, Geology, part ii. p. 485).

Crossing the Bosphorus, we have the same testimony. Boué, in his great work on European Turkey, says distinctly that the phenomenon of erratic blocks is foreign to the two Turkeys, *i.e.* Asia Minor and Turkey in Europe, as it is in all the south-east of Europe (La Turquie d'Europe, vol. i. p. 395).

In an elaborate memoir on the geology of European Turkey, published in 1876, in the 20th volume of the Austrian Geological Society, F. Von Hochstetter quotes Viquesnel for the statement that neither in the Izker valley (vol. ii. p. 373) nor in that of the Rielska Reka above Rilo Selo (vol. ii. p. 374), nor in the upper Mesta valley (vol. ii. p. 366), do these deposits bear any resemblance to moraines. Hochstetter says, "I can confirm this view of Viquesnel," and he goes on to show how easy it is sometimes to mistake a great mass of débris, the result of an avalanche, for a moraine, as in the case of a mass of granite blocks 10 mètres high in the valley of Rielska Reka, and he concludes, "Der Rilo, das höchste Gebirge der östlichen Türkei, hat ebenso wenig eine Getscherperiode gehabt, als der Balkan" (*op. cit.* pp. 460–461).

Neumayr is equally emphatic, and I will quote a passage from his well-known Erdgeschichte, published in 1887:—"No unmistakable traces of glaciation have as yet occurred in the Balkan Peninsula where they quite fail, except in the fact of the occurrence of some mountain lakes which may point to glacier action in the Kilo Mountains in South-Western Bulgaria. I myself have explored several of the high districts in Greece, Thessaly, and Macedonia, and neither on the Shar-dagh, near Uzkub, nor on Mount Athos, nor on Olympus, nor in the Ætolian Alps, nor in the Korax Mountains, have I found any traces which can be attributed to the work of glaciers (*op. cit.* pp. 598–599).

Moving northwards we have, in conclusion, to refer to the Carpathians. Traces of old glacial action have been diligently sought in this range, and more than one writer has described their existence; but they seem to be very local, if not doubtful. If they had been glaciated on a considerable scale, assuredly débris from their summits ought to be found dispersed over North Germany, which is literally covered with erratics that have come all the way from Finland and Scandinavia, where the mountains are for the most part very little, if any, higher.

Neumayr says that traces of glacier action of any importance are only to be found in the upper Tatra, that mass of serrated granite heights which extends between the districts of Zips and Leptan in Northern Hungary and Galicia. Long ago Zeuschner found traces of the moraines of an ancient glacier at Zakspan in the Tatra group, and in later times similar traces have been found on the south side" (*op. cit.* pp. 597–598). Neumayr gives a good illustration of these mountains, in which I confess I can see no traces of the ice plane in the rugged angular masses of granite, and I very much doubt the character of these so-called moraines which are so obviously inconsistent with the rough rocks above them. I notice also that Neumayr points out as the most striking evidence of old glacial action in the Carpathians the presence there of many mountain lakes, which, following in the footsteps of Ramsay, he attributes to glacial causes, a view in which a large number of geologists cannot share.

Turning to other parts of the Carpathians, Neumayr says quite frankly that though traces of glacial action are not entirely absent, yet they are insignificant (anbedeutend). In the Liptan Mountains, he says, are some uncertain traces; but he himself had failed to find any evidence over a considerable stretch of the Central Carpathians. Paul and Tieze had, however, noticed some moraines on the Cherna hora, the highest part of the Eastern Carpathians, 2007 metres high, whence the Theiss and White Pruth spring (*id.* p. 599).

It seems to me that the evidence forthcoming to show that the Carpathians partook in the general glacial phenomena which have left such important and unmistakable traces in the much inferior ranges further west, such as the Vosges, the Morvan, etc., is quite unsatisfactory and insufficient, and that the problem should be again examined on the spot by some inquirers who do not mistake every heap of rolled stones for a moraine. It is incredible to me, if the Carpathians had existed in the Glacial age at the time when the mountains of Scotland and Ireland and Cumberland were loaded with ice, that we should have to search so minutely over them for any real traces of ice action, and to be actually limited to finding them on two or three of their higher peaks. The view that the further we go east in Europe, the smaller do the traces of glacial action become, had already occurred to others.

Penck says that Peschel was the first to observe (Volkerkunde, 1877, p. 43) that traces of glacial phenomena diminish in Europe as we go East. Of the three South German mountain ranges the Vosges present the greatest traces of glaciation, while in the Alps the intensity of the phenomena diminishes as we go East, and the Western Alps must have been more thickly covered with ice than the Eastern. The same is the case in America; only that there the intensity of glaciation diminishes as we go west. While the low-lying lands in the east of that continent were covered with ice, the mountain region on the west coast only harboured local glaciers (Penck, Vergletscherung der Deutschen Alpen, p. 438).

The evidence seems to me to point to the Carpathians being a very recent feature in European physical geography, and, as in the case of the Balkans, the Taurus, in Asia Minor, the Caucasus (perhaps the Lebanon and the Atlas), and the Elburz Mountains, to their not having been in existence during the Glacial age, of whose unmistakable handiwork they bear no adequate traces.

I have endeavoured in the recent papers which you have done me the favour to print to meet the demand of those geologists who have asked me for a cause competent to produce such a diluvial movement as I have postulated at the close of the Mammoth age, and which seems to be attested by a great mass of evidence. I have tried to collect a certain number of facts to show that at the close of the epoch in question there was a very violent and widespread dislocation of the earth's crust, which led to the upheaval of some of its loftiest mountain chains. This upheaval was accompanied, as I believe, by an equally rapid and substantial subsidence in other places, of which also there is much evidence, some of which you may perhaps permit me some time to print. It was in my view by a combination of these two movements that the diluvial phenomena to which I refer were produced. This cause is at all events an efficient one, and is therefore not like so many of the physical causes appealed to by the current school of Uniformity, both inefficient and transcendental.

V.—ON CERTAIN GNEISSES WITH ROUND-GRAINED OLIGOCLASE AND THEIR RELATION TO PEGMATITES.

By GEORGE BARROW, F.G.S.,
H. M. Geological Survey.

[Communicated by permission of the Director-General.]

IN the course of my work in the Highlands of Forfar, I have been much struck with the mode of occurrence of certain light-coloured gneisses, of undoubted igneous origin.

They are intruded into the surrounding rocks in an infinite number of thin bands or sills, generally interlacing, and often not more than two feet thick; sometimes not exceeding an inch. Their bulk in some areas exceeds considerably that of the older rocks, at other times it is far less.

Two points are easily noted; first, they have no selvage edge; secondly, they have a very characteristic aspect, due to rounded grains of oligoclase.

Commencing in an area where these characters are well marked, we find that the rock consists of oligoclase, muscovite, biotite, quartz, and microcline, but the last mineral bulks far less than the more basic felspar. It is the oligoclase that is so round-grained in form, and gives the rock its characteristic appearance. The micas, especially the muscovite, may easily be seen to have sharp angles.

Going southwards, that is, away from an area where gneisses predominate, we observe the round-grained character to become less marked, and the oligoclase to form a smaller proportion of the whole rock. Still further south, the gneissose character becomes less marked, the oligoclase is further diminished in amount, while muscovite begins largely to exceed the biotite.

In this phase the rock begins to be much permeated with coarse pegmatite, which forms a massive fringe to the southern edge of the gneiss, this fringe attaining in one case a breadth of 700 yards. The pegmatite consists essentially of microcline, quartz, and muscovite, the oligoclase being usually very small in quantity, and not visible to the unaided eye. That this rock consolidated much as we now see it is obvious from the vast area of contact metamorphism that accompanies its intrusion. How then was it produced? I learned the solution of the enigma from a normal granite. A common type of granite consists of potash-felspar, quartz, oligoclase and two micas; the first-named mineral usually attaining the greatest size, and being most striking to the eye. But examine a broad dyke, belonging to the same original magma, and its appearance is seen to be very different. The potash felspar is no longer visible to the unaided eye, but it forms with the quartz a finely granitic matrix, in which the earlier crystals of consolidation, the two micas and oligoclase, are porphyritically embedded. Still further, if the rock is slightly decomposed, the latter mineral, somewhat tabular in form with conspicuous development of the clinopinacoid, is seen to have an outer shell, fairly well marked off from the much more *rounded inner portion*. The oligoclase obviously came up in this form, and completed its growth from the magma in which it lay, which later portion has been shown by Prof. Sollas[1] to be more acid in character than the core. The round-grained crystals then, of our round-grained gneiss, want their outer rim of later growth. How is this to be accounted for? If such a granite-magma be intruded during or towards the close of a powerful earth-movement, it may be forced, by the tremendous pressure, into every possible plane of weakness in the surrounding rocks. Now, obviously, it is not the crystals, but the liquid portion of the rock that must enter first, and all the crevices must be opened to the diameter of the oligoclase crystals before any of them can enter. The acid portion then of the magma, containing the constituents of potash felspar, must travel somewhat in advance of the crystals of earlier formation. In addition, the continuance of the pressure will still further force the liquid from the solid crystals, leaving at last just sufficient of the magma to fill the interstices between them. Thus, in my opinion, has the perfect form of round-grained gneiss been produced, which is by no means uncommon. The more acid magma will travel furthest, and finally consolidate as pegmatite. Put back the pegmatite into the gneiss, and you have the composition of a normal granite. The round-grained character of the oligoclase is thus seen to be due to the draining off of the magma, from which it normally finishes its growth.

To turn now to the question of the absence of selvage edges to the gneiss. Obviously a coarse-grained intrusion of an inch in thickness would only be possible if the country rock were nearly at the same temperature as the magma. There is further evidence tending to this conclusion, but as some parts of it are matters of dispute, it may be omitted for the present.

From the foregoing remarks we may draw the conclusion that neither a round-grained gneiss of the above type, nor its accompanying pegmatite, is in any true sense a metamorphic rock; both consolidated as we now see them. In addition, it would be more accurate to describe the pegmatite as being *extruded from* the gneiss, than intruded into it. The latter view implies a later date, while both are obviously of the same age. Like any other rock, such gneisses and pegmatites are liable to *subsequent* metamorphism.

---

[1] See Prof. Sollas' paper, "Contributions to a Knowledge of the Granites of Leinster," Trans. Roy. Irish Acad. vol. xxix. p. 427.

VI.—ON THE CONTINUITY OF THE KELLAWAYS BEDS OVER EXTENDED AREAS NEAR BEDFORD, AND ON THE EXTENSION OF THE FULLER'S EARTH WORKS AT WOBURN.

By A. C. G. CAMERON;

of Her Majesty's Geological Survey.[1]

[Printed by permission of the Director-General of the Geological Survey.]

DURING late years, by the opening of new sections, fresh information has been obtained of the geology of different parts of the country, and several fine excavations, the result of railway enterprise, have afforded great sections of the Kellaways beds in localities where only conceptions of them previously prevailed. Gaps have been filled up, and the continuity of the beds over extended areas confirmed. The principal revelations come from the Hull and Barnsley, and from the Swindon and Cirencester railways, opened respectively about 1881 and 1883, and the works now in progress in connexion with the widening of the main line at Oakley, near Bedford. There are records too of deep sinkings and borings, away from the outcrop, that indicate an area for the Kellaways as extensive as that of the Oxford Clay itself—and in the Midlands a more than usual thickness is reported; the Bletchley boring of 1886 specially indicating this.

From Wiltshire to the bold cliffs of Gristhorp and Scarborough Castle, along the great sweep of Oxford Clay, this immense sand-bank—if it is such—is well enough indicated, and, when hidden beneath the Fens, the Humber flat, or the Drift, is unquestionably accounted for.

Probably the earliest reference to the Kellaways comes from Boston, in Lincolnshire, where, in 1783,[2] the Oxford Clay was penetrated 470 feet, and then sand, to a depth of 8 feet, when the boring was abandoned as the water which then rose proved to be salt.

About that time, too, William Smith observed at Kellaways Bridge, in Wiltshire, a stone being quarried for road-metal that "occurred in irregular concretions, the exterior aspect of which is brown and sandy, the interior being harder and of a bluish colour. It consists almost entirely of a congeries of organic remains. The beds of clay which cover this rock abound in selenite, and below are beds of clay again."

The late Mr. Bristow informed me that there is no Kellaways Rock now at Kellaways, it having been all quarried away at its outcrop, for road-stone, years ago. Local stones were much more used in olden times than now, owing to the difficulty of transporting road-metal; thus the rock at Kellaways was then used for that purpose.

Briefly reviewing the past literature of this formation we find that, owing to the absence of sections along its course and the difficulty in consequence in tracing it, it was alluded to as being of partial occurrence only, and, if not entirely wanting in the Midland districts, at least so attenuated as to be inseparable from the Oxford Clay. For reasons such as these the Kellaways were not known in Bedfordshire until of late years—nothing of the kind having been recorded; the preponderance of yellow sand and loam on the sides of the valley around Bedford being looked upon as an extension merely up the slopes of the sand and gravel prevailing in the town. Large areas of building land have recently been covered with houses at Bedford, and there is a constant demand for bricks and lime. Brickmaking is carried on with energy, and the brickfields and stone-pits are prominent objects of interest in the neighbourhood of the town. Pits are opened at the outcrop of the Kellaways and carried down into Great Oolite through Lower Oxford (selenite clay), Cornbrash and purplish Cornbrash clay. In the making of bricks the Lower Oxford and the Kellaways loam or "lam earth," as it is called, are mixed, lessening the liability in the clay to contract and crack in drying, as happens when the Lower Oxford, the 'strong' clay, is used alone.

---

[1] An abstract of this paper was read in Section C, British Association, Cardiff, 1891.

[2] Phil. Trans. vol. xvi. p. 183 (1785).

These Oolite divisions are seen to great advantage in the valley of the Ouse, as they lie upon each side of the river. Those extraordinary concretionary stones that characterize the Kellaways, jut out in the valley and stand about in some brickyard sections, in clusters, like gigantic fungi.

There is an admirable display of these singular stones at Oakley Hill, near Bedford. The railway passes in a cutting there through a tongue of land that juts out into the valley from the amphitheatre of hills around, and the cutting which is now being widened and cut back towards the hills, has laid bare a considerable length of Upper Oxford, Kellaways rock and sand. The base of the Kellaways is not reached, but outcrops lower down with other underlying beds, round the flanks of the hill. Big stones, smooth and rounded, stand out in relief in the sides of the cutting, the effect being heightened by the softened aspect and sombre hues of the clay above. These also stood in rows upon the sand before being broken up, to make way for the rails. One of the workmen likened them to boulders put down for stepping-stones, adding that there must have been "a flood there at one time." Some of these huge stones measure thirty feet in circumference. Where the sand is dug away and they stand each upon its own pedestal of sand, the resemblance to prodigous mushrooms is almost more than fanciful. Sometimes two stones are joined by a neck forming twin stones, when this semblance is lost in the figure of an hour-glass or the number eight. Where many stones are near together—and there are twenty or thirty now and then—these all but form beds of hard sandstone.

In some cases they are isolated and bare on the bright yellow sand, and the mind reverts to the sea and the sands and the blocks of stone one sees there when the tide is out.

Prof. Harker gives an account of the Kellaways beds exposed in the railway cutting at South Cerney, near Cirencester, and with these the beds at Oakley are identical. The shelly bands in the Bedford sections have, however, a direct bearing on the concretionary origin of these stones, as set forth by Prof. Harker, that is not mentioned in his paper. The Upper Oxford and Kellaways beds in the Bedford sections are divided by a shelly calcareous band in contact with a shelly cap to the concretionary stones. Where this line is a broken one, there is no development of concreted rock below, and by gradations the Oxford Clay passes into silt and sand, seemingly indicating the piling up of the shells at particular spots as would happen on a shore exposed to strong currents; the subsequent decomposition of the animals resulting in the sand beneath being concreted into hard rock, as Prof. Harker says. The sand seems to have had deep water over it, as there do not appear to be any fossils whatever in it. On the other hand, the concretionary stones are—externally anyway, as Mr. Smith says, "congeries of organic remains."

All the animals, except the Belemnites, seem to have died young; *Serpulæ*, so conspicuous on other Oolite shells, are entirely wanting. There are shelly bands wholly made up of *Belemnites* and *Gryphæa*, while *Ammonites*, *Aviculæ*, and other forms besides, adhere to the upper surface of the doggers in great profusion. Pieces of this rock are more like Kentish rag than any other stone I know. A variety of *Gryphæa dilatata* occurs in such abundance and so like *Gryphæa incurva* in the Lias, that one would think the destruction of these beds could have contributed shells of *Gryphæa* to the Drift, as easily as the Lias. Although a hard rock when dug at any depth, the Kellaways becomes rapidly friable and crumbles on exposure; and where these stones jut out naturally, the shelly cap is usually gone.

There is an indurated seam of sandy marl above the shelly band at Oakley, which breaks into conical forms, exhibiting the structure known as cone-in-cone. The broad surfaces of these cones are upwards, ending against the Oxford Clay.

I saw no instance of the apices pointing towards each other; and the whole series stand vertical in the stratification with the points downwards, or to the bottom of the seam. It is difficult, therefore, to conceive of these cones being due to the upward escape of gases —as suggested by Mr. John Young of Glasgow,[1] although these would be emitted; the decay of the dead animals being sufficient to generate gases in the deposit whilst the bed was in process of formation.

Throughout this seam the texture of the stone is more or less fibrous, and in the phenomena of the cones the fibres seem united into tufts, which taper downwards and end in a point; rather resembling some stalactitic infiltrations.

The tract of land occupied by the outcrop of the different Kellaways beds, although of necessity only a narrow band, presents changes in the character of the soil marked enough to be known by distinct local names.

---

[1] Geol. Mag. Vol. II. June, 1885, on Cone-in-Cone Structure. Abstract of paper read to Geol. Soc. Glasgow.

The long narrow sandy piece on the slopes that reach the Boulder-clay (and its breadth expands in places) is 'white land,' easily recognized even at a distance in dry weather, from its colour. Again, the zone next the white land, and between it and the stony (Cornbrash) soil, farmers and others call "lam earth" or loam. This is the horizon, too, in which the brickfields are opened.

There is nothing in these soils, viewed agriculturally, to force the growth, and they are therefore almost useless for cropping; yet it is healthy grazing land, and cattle do well on it. Compared with other mild clays, the coldness of the "lam earth" or silt is in excess. It is not unusual to find osier beds attached to the brickfields, and willows planted at particular spots where any considerable development of silt occurs; in such cases osier beds thrive on the hill-sides equally well with those upon the water-meadows.

Mention has been made of a saliferous rock in Bedfordshire, in the lower part of the Oxford Clay, yielding a saline water containing large quantities of salt. It is doubtful whether the true seat of this water is in the Kellaways or in the underlying Oolites. It seems, however, certain that the saltness is considerable where the Kellaways is thicker than usual. At the same time, even a larger quantity of chlorine existing in the form of common salt occurred where the water was obtained from rocks that underlie the Kellaways beds.

The great value of our salt springs is for baths, and therefore the directors of an establishment in the educational centre from which I write, are to be congratulated on their recent discovery. There is no reason for ascribing any unusual thickness to the Kellaways beds of Bedfordshire; nor any serious quantity of salt. I think myself that the "sandy bed with big stones" is well known to well-sinkers in the clay districts as a trustworthy and palatable water-bearing stratum, beyond which they have no need to sink—that is for the requirements of any ordinary supply.

The borings at Swindon and Bletchley, as a search for water, were failures; the water in both cases being very salt. Far down, however, in these bore-holes great developments of Kellaways beds were discovered under several hundreds of feet of clay. Concerning Swindon, the publications in 1886 (the boring was made in 1875) show the water to have come up from the Forest Marble, and it was near this horizon that the water at Bletchley was found.

Notices of this boring appeared[1] in connection with a report that the borers, after passing through the Oxford Clay, had come upon granite or granitic rock.

Pieces of granitic rock did come, it appears, from these depths, but there is no proof that the whole of the thickness assigned to granite consisted of that rock. I passed all the samples myself as Kellaways sand and stone. It has, however, been suggested[2] that the Kellaways beds beneath Bletchley may include granitic blocks and boulders embedded in the sand.

---

[1] See Geol. Mag. Dec. III. Vol. IV. p. 139 (1887), Prof. Hull's letter; Dec. III. Vol VI. p. 356 (1889), A. Jukes-Browne, On the Occurrence of Granite in a Boring at Bletchley.

[2] Geol. Mag. Dec. III. Vol. VI. p. 360 (1889), Granite in Boring at Bletchley, A. Jukes-Browne.

The hardness of the Kellaways when dug at any depth might well account for the incessant pounding and tediousness in making this boring. Prof. Harker describes the Kellaways stone as "obstinate," blunting the chisel of the excavators, and resisting any forces but dynamite and gunpowder. Should other borings afford no further information, Granite in the Bletchley Boring will remain unique in our local geology. and justly excite much wonder.

North of the Humber, where the lands bulge out at Drewton-on-the-Wolds and overlook the Humber flat, there is a greater thickness of Kellaways sand than has been observed throughout the central plain of England. At the Drewton cutting of the Hull and Barnsley railway, there is a tendency throughout of the sand to consolidate. Big boulder-like stones are not, as before, the most prominent feature, being replaced by blocks of tough siliceous sandstone weathering out in planes amongst the softer beds of sand. Above are fossiliferous beds of hard ferruginous sand, giving a very brown and irony look to this cutting.

From this point northwards the rocky character of these beds is maintained, and the Kellaways, if lacking in the peculiarities developed in the south, leave England with importance on the Yorkshire coast.

Since writing the above paper I see that Conybeare and Phillips, in describing the Lias, state that "irregular beds consist of fibrous limestone and cement stones (septaria), so called because used in making Parker's cement. Where the fibres are not parallel to each other, they often form that irregular substance so common in the Coal-measures, to which an organic structure has often erroneously been attributed and termed the cone-in-cone coral."[1]

OBSERVATIONS ON THE EXTENSION OF THE FULLER'S EARTH WORKS, AT WOBURN SANDS.

Fuller's-earth possesses remarkable grease-absorbing and cleansing properties, which places it foremost amongst the list of mineral detergents. The water thrown out by this formation is very soft and pure, and blocks of the earth have been placed in wells to purify the water. A superior quality of Fuller's-earth is procured from the Lower Greensand at Apsley Heath, in Bedfordshire.

Until lately the means adopted to work this mineral consisted simply of cylindrical holes in the sand, called "earth wells," or merely "wells," dug down to the Fuller's-earth, and without lining of any sort, and of these there were but two.

The operations now in progress bid fair, however, to give rise to no small stir in the place.

On the brow of this hill are the offices of the Fuller's-earth Company, with kilns for drying, and grinding mills used in the preparation of the earth. Sinking and shafting and the laying-out of underground works are carried on; and the little waggons with their loads of "earth" are gliding up and down the steep hill-side. Apart from its being a source of wealth and industry in the country, this extension at Woburn of the Fuller's-earth works is an interesting item in Bedfordshire geology, and the borings will determine probably the general arrangement of this mineral, regarding which, up to the present time, no particular notice has been taken.

---

[1] Outlines of the Geology of England and Wales, p. 264 (1822).

VII.—THE MANUFACTURE OF SERPENTINE IN NATURE'S LABORATORY. A REPLY.

By Major-General C. A. MACMAHON, F.G.S.

PROF. BLAKE, F.G.S., President of the Geologists' Association, has been good enough to send me cuttings from his recently published work "Annals of British Geology" containing his running comments on papers by me published during the period embraced by his volume, and for which I desire to tender him my best thanks.

I think it will be more courteous on my part to offer a few observations by way of reply to Prof. Blake's criticisms than to allow them to pass in silence; but I must confine myself to one paper, by way of sample. I select that bearing the title at the head of this communication (published in the Proc. Geol. Assoc. vol. xi. p. 427), as the subject discussed in it is of general interest to geologists.

The first extract from the Annals of British Geology I select for comment runs as follows:—

"He then enters into the chemical question, and explains how carbonic acid will decompose silicates of magnesia and iron. The principal mineral altered being olivine, he shows that if from 2 molecules of this $(MgFe)_4\ Si_2O_8$, one molecule of ferro-magnesian oxide is removed, $MgFeO$, and two molecules of water added, H_4O_2, we get Serpentine, $H_4\ (MgFe)_3\ Si_2O_9$, but 'as this involves an increase of volume some silica may also be removed.' This last suggestion will, of course, alter the above, and bring it into harmony with the method suggested by Roth, as quoted by Teall (Brit. Petrography, p. 106), *i.e.*, 5 molecules of olivine$=10\ MgO+5\ SiO_2-(4\ Mg\ O+Si\ O_2)+4\ H_2O=6\ Mg\ O,+4\ Si\ O_2+4\ H_2O=2$ molecules of Serpentine."

The sentence "as this involves an increase of volume some silica may also be removed" is marked by inverted commas and professes to be a quotation from my paper. Prof. Blake employs inverted commas, apparently, in order to convict me of a blunder out of my own mouth; the word "also" implying that some silica may have been removed from the *two molecules* of $(MgFe)\ O_2\cdot\ Si\ O_2$ in addition to the molecule of ferro-magnesian oxide; and as the loss of this silica is not shown in my account of the *two molecules* of olivine, my calculation must be wrong.

Strange to say, the passage quoted under inverted commas does not occur in my paper. Not only did I not write the sentence given as a quotation, but it involves a serious misrepresentation of the views expressed in my paper.

What I actually said is as follows: "As the above change [viz. the conversion of two molecules of $(Mg\,Fe)\,O_2.\ SiO_2$ into $H_4\,(Mg\,Fe)_3\,Si_2O_9$] appears to involve an increase of volume, I think it probable that the passage of carbonated water through olivine results in the removal of some of the ferro-magnesian silicate [viz. *Olivine*] (without conversion into serpentine) in the form of soluble silica and carbonates." My argument then was this: Olivine is a silicate of magnesia and iron. Its conversion into serpentine involves hydration and an increase in volume; it is therefore probable that a portion of the olivine is removed *without conversion into serpentine* in the form of soluble silica and as carbonates of iron and magnesia. My account therefore (to borrow a book-keeping term) only applied—and I thought that was sufficiently evident—to that portion of the olivine that remained behind and suffered conversion into serpentine.

Suppose a parent gives a gold sovereign to his son but at the same time takes back from him five shillings in silver; what would be said of his logic if the parent subsequently called upon his son to render an account of his expenditure, and proceeded on the assumption that the boy had spent twenty shillings of his parent's money on "tuck"? Would not the boy be right in saying, "Why, I gave you back five shillings, and I have only to account for fifteen!" Yet the parent's position in my illustration is Professor Blake's position with reference to his criticism on my paper. I have humbly tendered my account of the fifteen shillings—straight and square—but Prof. Blake says, in effect, "That is all very fine, but your account of the fifteen shillings must be wrong, because you admit having given us back five shillings out of the sovereign!" Those are not his words, but that is what his criticism comes to.

In another part of his abstract Prof. Blake writes as follows:—

"The entrance of water into permeable rocks is easy to understand, but beyond this, it finds its way into the heart of the hardest minerals. The writer introduces Boscovitch's theorem, that molecules within a certain distance have a repellant rather than an attractive force, in order to show that there must be molecular interspaces in minerals. Since the alteration of these minerals begins sometimes in the centre, when the channels through which chemical constituents have been abstracted or introduced are too small to be revealed by the microscope, he thinks they must have come in by these invisible pores [in which case, why do they not alter the outside as they pass by?]."

The objection raised by Prof. Blake is one easily met. Now-a-days, when we can not only study thin slices of rocks under the microscope, but also isolate the minerals of which these rocks are composed, and subject them to chemical analysis apart from the mass of the rock, petrologists have come to recognize the fact that a gradual change, more or less pronounced, frequently takes place in the chemical constitution of the uncrystallized magma during the gradual cooling and consolidation of an igneous rock. Some minerals crystallize in advance of others, and in doing so withdraw from the magma a lion's share of some of the chemical constituents. It may be a selfish thing to do, but, in this sense, some minerals are habitually selfish. The usual rule is that the more basic minerals separate first, and consequently those last formed are more acid than the minerals of the "first generation."

Owing to the progressive alteration of the magma brought about from the above cause, a gradual change in the composition of minerals of slow growth may, and often does, take place in the course of their formation; and this modification is marked by corresponding changes in their physical characters, such as colour in transmitted light, and optical properties. Hence what is known to microscopic-petrologists as zonal structure is commonly observed in the minerals of certain rocks—a structure so marked that it sometimes carries with it a progressive change in the angle of extinction from the centre to the periphery of the crystal, indicating in extreme cases a change in the mineral species. Now where, as explained above, the magma becomes more and more acid as comparatively basic crystals separate out from it, the centre of a mineral of slow growth would be more basic than its peripheral portions; and the centre would be more susceptible to the attacks of aqueous agents than the periphery, because the more basic a mineral is, the more readily it succumbs, as a rule, to ordinary corrosive agents.

Variations from the normal type are even more common in the mineral than they are in the animal world, and a very slight difference, no matter from what cause it may arise, in the composition of one crystal as compared with that of another of the same species, or in one part, as compared with another part, of the same crystal, may suffice to give temporary immunity from the attack of a highly dilute acid. The corrosive agent makes for the weak spot, and exhausts itself on the material there before it attacks the less susceptible material in other places. Hence we often see in the examination of thin slices of rock under the microscope, that whilst one olivine has been more or less completely converted into serpentine, another by its side has been left untouched; and whilst part of a crystal has been converted into the hydrated mineral, the rest has successfully resisted conversion into serpentine. Had the process not been arrested, the less tractable olivines would ultimately have been conquered.

In view of the above facts, if we grant that water can find its way through the pores of a mineral, I see no difficulty in understanding why the central portions of some minerals should yield to water charged with carbon dioxide, or other chemical reagents, before the peripheral portions.

I have not alleged, however, in my paper, that the central portion is always the first part attacked. I wrote:—"This alteration does not always begin at the outside of a mineral, and every microscopic petrologist will be familiar with cases in which it has been set up at the heart, and in the internal tissues—so to speak—of a mineral, and when the channels through which chemical constituents have been abstracted, or have been introduced, are too small to be revealed by the microscope." As a matter of fact, the alteration sometimes begins from the outside. In cases in which an olivine is perfectly homogeneous in chemical composition, one would expect this to be the case—the attack begins from the outside, and works its way slowly and gradually into the interior through "planes of easy solution," or any other planes of weakness, that may exist. When there are actual cracks, the liquid reagent is not too proud to avail itself of the aid afforded by them in the work of sapping its way into the heart of the fortress.

As for the question whether water under pressure, and under the conditions that obtain below the surface of the earth, can penetrate into the inner pores of a mineral, I must refer the reader to my paper under discussion, and to the instructive papers by Prof. J. W. Judd, F.R.S., on schillerization and kindred subjects. "We must never forget," he writes in one of his papers,[1] "that in the deep-seated rocks . . . . the whole mass, crystals and base alike, must be permeated by liquids and gases." Cracks we can see under the microscope readily enough, and no petrological microscopist is likely to ignore their existence or the part they play in the circulation of underground waters. I likened them in my paper (p. 431) to the small veins and arteries in the human body; but we want something in the mineral world to correspond with the minute capillary pores through which blood finds its way between the ultimate cells of which the animal body is built up. We cannot see the atoms, or even the molecules, of which minerals are composed; but we can infer the existence of molecular interspaces, and we can assure ourselves of the fact that water, under pressure, actually finds its way into these molecular interspaces by what lawyers would call circumstantial or indirect evidence. For instance, when we find *hydrous* minerals occurring in the interior of the mineral constituents of igneous rocks, and when we have independent evidence that these hydrous minerals are of secondary origin, we must admit that water worked its way into the heart of the altered mineral after its birth, unless we are prepared to show that the parent crystal originally contained enough water to supply the total quantity contained in the parasitical minerals generated in its tissues, as well as *all* the chemical constituents contained in them. The subject is too large to enter into here.

Prof. Blake proceeds as follows:—"Minute cracks, however, are also present, as is shown by granite and greenstone absorbing water, and containing air, and the capillary action is increased by pressure and heat. [He seems to think, however, that the same conditions would facilitate the introduction of water into the intra-molecular spaces, since] 'heat signifies an increase in the force of repulsion that keeps apart the atoms [*sic*] and molecules of which these minerals are composed' [in which case, heating should make a compound take up more water, but, *e.g.*, 'the hydrate of sodium sulphate is more and more thoroughly converted into the anhydrous salt as the temperature increases.' (Fownes.)]"

---

[1] Q.J.G.S. 1889, p. 181.

From Professor Blake's insertion of "[*sic*]" after atoms, I infer that he regards a molecule as a homogeneous, solid body like a bullet, as it appears to our unaided vision; if so, his conception of the constitution of a molecule can hardly be considered "up to date," as the following brief extracts from two well-known works will show. "Atoms cannot be divided physically; they are retained side by side, without touching each other, being separated by distances which are great in comparison with their supposed dimensions. A group of two or more atoms forms a molecule."[1] "Nor should it be forgotten that, granting the fundamental hypothesis of the molecular and atomic theory, and also granting that each atom can directly interact with a limited number of atoms in a molecule, we are obliged to regard the atoms which form any molecule as performing constant regulated movements, and not as might be supposed by a careless or superficial reader of the atomic explanation of isomerism, as in absolutely fixed positions within the molecule."[2]

According to modern conceptions, therefore, the atoms which constitute a molecule are linked together, but the linking is analogous to that of moons to a planet, and of a planet and its moons to the sun.

The illustration which Prof. Blake adduces, at the end of the above extract, in support of his objection, seems to indicate a fundamental misapprehension on his part. The case of the hydrate of sodium sulphate seems to me to have no bearing on the point at issue. In my paper I discuss the mode in which the *hydration* of a specified silicate is brought about in a rock below the surface of the earth in the presence of water under considerable pressure; and Prof. Blake opposes the case of the dehydration of a salt by heat under ordinary atmospheric pressure at the surface of the earth, and in the absence of water. There seems to me to be no analogy between the two cases. We all know that at the surface of the earth calcium carbonate can be converted into lime (CaO) by raising its temperature to a certain point; because at that critical temperature, the force of repulsion, generated by the heat, overcomes the force of the attraction between the calcium oxide and the carbon dioxide, and the latter passes into the gaseous state. Under plutonic conditions, on the other hand, the carbon dioxide remains in union with calcium oxide, and crystalline calcite is formed.

In my paper I was considering the question of capillary flow under heat and *pressure.* I showed that, "although the pressure under which water is put in circulation through the capillary pores depends on the head" ("·43 lbs. per square inch per foot in height"), "the freedom with which this water flows through the capillaries" must, with reference to the experiments of Poiseulle, be increased by heat. I contended, therefore, that if "the pressure under which water is being injected into the pores of a mineral remained constant, heat would facilitate the capillary flow through those pores by reducing the resistance to the passage of the water." It is no answer to this contention to say that under totally different conditions water is driven off from the hydrate of sodium sulphate by the application of heat. Prof. Blake might as well argue, it seems to me, that marble could not have been formed under plutonic conditions, because, at the surface of the earth, and under the pressure of one atmosphere, the application of sufficient heat will result in the carbon dioxide being driven away from calcium carbonate. It does not require much chemical knowledge to know that if you alter the conditions you may expect to obtain different results.

---

[1] Ganot's Elements of Physics, by Atkinson, p. 1.

[2] *Principles of Chemistry, by Patteson* Muir, p. 154, footnote.

VIII.—A REPLY TO PROF. BLAKE'S COMMENTS ON INFERIOR OOLITE AMMONITES.[1]

By S. S. BUCKMAN, F.G.S.

PROF. BLAKE'S book is a valuable work of reference; but the criticisms appear to be both hurried and inaccurate. In the notice of my Monograph the title is incorrectly given: there are certain other clerical errors; and some mistakes which a little more investigation would have prevented.

While placing his comments in brackets, it is unfortunate that Prof. Blake has not found some means to distinguish between remarks based upon the author's words, and statements of his own. This is especially noticeable in the "critical digest" of *Haugia*, where remarks, which appear as if they originated with Prof. Blake, are really my statements in another form.

Some of Prof. Blake's principal comments invite reply. For the sake of brevity I will place them in italics between inverted commas.

"*The meaning of species and genera . . . . is of the most restricted kind . . . their distinctions arbitrary.*" As to the species, the charge does not seem to be sustained in the part reviewed; for out of twenty-seven species described I am only answerable for five. I have also combined as one species forms which a German author regarded as three; and in other cases I appear not to have made enough species to please my critic.

The genera are restricted I own; it is part of the plan of the work. I regard species as various developmental gradations. I look upon genera as groups of species in more or less direct genetic connexion, possessing certain features in common. Since species in direct genetic connexion—and therefore genera—arose one from another by the accumulation of successive slight modifications transmitted in accordance with the law of earlier inheritance, the distinctions between species or genera in direct genetic connexion must be arbitrary at certain points. I have always admitted this; but between the homoplastic developments which result from the operation of similar economic laws on the heterogeneous descendants of a remote common ancestor, the distinctions are not really arbitrary, though they may appear to be so. It is unfair to adversely criticize genera by comparing, say, the senile metamorphoses of different phylogenetic series. Such degradational forms have lost, to a certain extent, the special features which distinguished the acmic species of their genera. But a system which recognizes the true biological relations of these homoplastic forms by placing them in separate genera is far less arbitrary and far less unnatural than the Waagenian system which Prof. Blake introduced to English readers,[1] in which homoplastic forms were arbitrarily dragged into the same genus on account of similarity of outward shape, while their true genealogical affinities were completely misunderstood. My efforts towards a natural system of grouping founded on an interpretation of Ammonite genealogy may not be correct at their first start; but I hope we may never return to so unnatural a grouping as was expressed by *Aegoceras*, *Arietites*, and particularly *Amaltheus*. "*H. occidentalis has no tubercles,* [*and therefore should belong to another group*]." Why? No new feature is introduced. There are no tubercles in senile "*variabilis*," or in adult "*jugosa*," and none in "*occidentalis*" at any stage. It is an illustration of the law of earlier inheritance. Had this loss of a feature been accompanied by the appearance of some new character, I should have been inclined to erect a new genus; but in a simple case of decadence like this I did not see the necessity.

---

[1] The Annals of British Geology, by J. F. Blake, M.A., F.G.S., p. 308, 1891.

A definition by Dr. Haug is given, with which, it is said, my figures do not agree, as they show no fasciculed ribs. I do not know if this be a case of my descriptions "*not agreeing with the author's original definition*"; but this is not original—it is a quotation from a letter. I have pointed out (page 154) that my figures do not bear out these remarks; but in Haug's *original* definition and figure of *H. occidentalis* fasciculed ribs are not noted or shown.

"*H. Eseri.* [*The author's figures include several species, none of which agree with the type*]." What, not figs. 3, and 4, pl. 25 with Quenstedt, Ceph. pl vii. fig. 9 *a-b*?[2] Dr. Haug wrote to me, May, 1890, "Vos *H. Eseri* de la pl. 25 sont tout-à-fait typiques."

The suture-line "*fig.* 6, *pl.* 35," is not normal, the siphonal lobe being to one side.

"*G. mactra* and *D. Moorei*" are degraded forms, and not fair samples by which to test the genera.

"*G. aalense, vars. a–δ* [*no proof given that they are the same species*]." I have yet to learn how it can be *proved* that certain forms are of one species or not.

"*G. subquadratum identical*" with *Saemanni*, "*differences assigned not borne out by figures.*" Similar remarks are made about other species in this "critical digest." I will take this as a sample. The differences given are (in *subquadratum*) coarser, more reflexed ribs, stronger inner margin, deeper umbilicus more slowly-coiled" (page 202). I think that these differences are all very noticeable in the plate—especially the slower-coiling, if any one will measure the figures with compasses.

---

[1] Ceph.; Yorkshire Lias, 1876.

[2] Allowance must be made for a slight discrepancy in the drawing of the inner margin in Quenstedt's two figures.

"*G. Saemanni* [*but apparently including as var. β another solid-keeled species*]." This is a most curious criticism in face of the explanation of the plate, and the fact that these forms are expressly included in the hollow-carinate section of the *Grammocerata*. I wrote to Prof. Blake asking him if he had mistaken the carina on the core (pl. 34, fig. 2) for the true carina. His reply rather astonished me—it showed that he did not understand the structure of a hollow-carina. He "thought it was the presence of a keel in the shell, but not on the cast," which made a hollow carina. This is certainly not the case: it is the presence of a partition-band overlying the abdominal part of the cast containing the siphuncle. The partition-band connects the inner walls of the overlying elevated carina, and so there is formed a hollow triangular tube around the periphery of the Ammonite. The abdominal part of the core may be carinate or rounded—this does not affect the structure of the hollow-carina in the least. I fully explained the structure of the hollow-carina in my Monograph, page 81, footnote, and illustrated its various phases in pl. A. In fig. 47 of that plate I figured a carinate core bearing a hollow-carina, and this feature is to be very frequently noted in the genera *Witchellia*, and *Sonninia*, as well as in *Grammoceras*.

A desire not to occupy too much space alone prevents me from replying to all Prof. Blake's criticisms; but from the above remarks I leave it to be judged whether the critic in an attempt to correct the author has not himself fallen into errors.

REVIEWS.

I.—CONTRIBUTIONS TO THE PALÆONTOLOGY OF SICILY.

THE CRUSTACEA OF THE FUSULINA-LIMESTONE OF THE VALLEY OF THE SOSIO RIVER IN THE PROVINCE OF PALERMO, SICILY. By Prof. G. G. GEMMELLARO.

I CROSTACEI DEI CALCARI CON FUSULINA, DELLA VALLE DEL FIUME SOSIO, NELLA PROVINCIA DI PALERMO IN SICILIA. Memoria di Gaetano Giorgio Gemmellaro, Professore di Geologia della R. Università di Palermo. Memorie delle Società Italiana delle Scienze fisiche e matematiche, Tomo viii. ser. 3, No. 1, pp. 40, and 5 plates. 4to. Naples, 1890.

THE author refers this Fusulina-limestone to the "Permo-Carboniferous" formation, and finds in it the following fossils.—I. TRILOBITES: *Proetus*, Steininger, 2 new species; *Phillipsia*, Portlock, 4 new species, and of the "subgenera" *Griffithides*, Portlock, and *Pseudophillipsia*, nov., one new species each.

If Prof. Gemmellaro is correct in his determination of these beds, then these Trilobites are younger than any hitherto discovered, and later than the true Carboniferous in age.

II. Macrurous Crustacean. *Palæopemphix*, gen. nov., with three new species. These carapaces doubtless belong to some small Macrurous Decapod, but it is not easy to recognize their ancestral relationship to *Pemphix* of the German Muschelkalk. The rostral portion of the carapace is curiously stunted (as in the *Crangonidæ*), and the antennal (antero-lateral) angles very prominent. These Sicilian forms are all seen *in profile*, but most of the early Carboniferous genera had the carapace flattened out, dorsally, as in the *Eryonidæ* of the Liassic and Oolitic period, and in the recent *Polycheles*.

III. Brachyurous Crustaceans. *Paraprosopon*, gen. nov., with one new species. This seems to belong to the genus *Cyclus* of De Koninck, and closely resembles *C. Jonesianus*, H. Woodward, in particular (see Geol. Mag. 1870, Vol. VII. Pl. XXIII. p. 558, Woodcut, Figs. 1–2).

IV. *Oonocarcinus*, gen. nov., with 3 new species. This form, according to the author, has its nearest ally in *Hemitrochiscus paradoxus*, Schauroth. It has, however, very much of the form of *Caryon*, Barrande, and reminds one of the head in *Sphærexochus*. But most of all *Oonocarcinus* resembles the coalesced segments of the buckler-like abdomen of the female in the *Leucosiadæ* (cf. Bell, Mon. *Leucosiadæ*, Trans. Linn. Soc. 1855, vol. xxi. p. 277, pls. xxx.–xxxii.).

Perhaps it may represent a part of an early Brachyurous Decapod; if so, it has an additional interest for us.

V. Ostracoda. *Cypridinella*, Jones & Kirkby, 2 new species; *Cypridellina*, J. & K., one new species; *Cypridella*, De Koninck, 2 new species; *Cypridina*, Milne Edwards, 2 new species; *Philomedes*, Lilljeborg, 1 new species; *Entomoconchus*, M'Coy, 1 new species; *Entomis*, Jones, 2 new species; *Beyrichia*, M'Coy, 1 new species. These have an exceedingly close resemblance to the true Carboniferous species of Britain and Belgium, and at first sight might in most instances be taken for them. The figured "*Beyrichia*," however, is a very doubtful specimen.

In bringing together the members of this most interesting local fauna, and illustrating it in so clear and admirable a manner, the author has done good service to Palæontology, and deserves our best thanks.

H. W. & T. R. J.

II.—British Pliocene Vertebrata.

"The Vertebrata of the Pliocene Deposits of Britain." By E. T. Newton, F.G.S., F.Z.S. Mem. Geol. Surv. United Kingdom, 1891, pp. i–xii, 1–137, Pl. I.–X.

THROUGH the generosity of the author we have been favoured with a copy of this valuable Memoir, which forms a companion volume to Mr. Newton's well-known work on "The Vertebrata of the Forest Bed Series of Norfolk and Suffolk," published by the Geological Survey in 1882. The Memoir also seems to have been prepared in connexion with another Survey publication by Mr. Clement Reid, "The Pliocene Deposits of Britain," said to have been issued in 1890, but of which we have not yet been privileged to receive a copy for review.

The Forest Bed Series of Norfolk and Suffolk being included by the Geological Survey among Pliocene Deposits, the new volume contains many observations supplementary to Mr. Newton's former work on the Forest Bed Vertebrata; and one double plate is devoted to the antlers of Cervidæ, of which no illustrations were previously given. The principal interest of the Memoir, however, centres upon the vertebrate fossils of the English Crags, which are carefully subdivided into horizons in accordance with Mr. Reid's classification. "By far the larger part of the Vertebrate remains which are said to be from the Red Crag really come from the Nodule-bed (Bone-bed of some authors) which occurs at its base; and, further, a Nodule-bed with similar fossils is known to occur also under the Coralline Crag. Many of the fossils from the Nodule-bed have been undoubtedly derived from the denudation of Eocene strata, while others seem to be the *remanié* of Pliocene beds older than the Coralline Crag, but of which no traces are known to occur in Britain. It has been suggested that most of the Nodule-bed Vertebrates have been derived from Miocene strata, but there seems little evidence to support such an idea. Many Vertebrate remains have been found actually in the Coralline Crag and Red Crag above the Nodule-bed. The same is the case with the Norwich Crag, many specimens being obtained above the Basement Bed. or Mammaliferous Stone-bed."

Many new specimens are noticed and well illustrated in the course of the work, but the majority of Mr. Newton's observations have already appeared elsewhere, and they are now presented merely in a collected form, with references to the original places of publication. These references, indeed, with those also to other authors, form the only blemish in the work demanding serious adverse criticism. They are all placed within round brackets in the text itself, and render many pages quite unreadable, except by the closest study. The nominative is frequently separated from the rest of a phrase by one and a half or two lines. Perhaps, however, the saving of the extra cost of printing footnotes results in some advantage, for the Memoir is issued to the public at the unusually reasonable price of four shillings.

It would be impossible in the course of a brief review to do justice to the most interesting and valuable mass of information concerning the Pliocene Vertebrata now brought together. It must thus suffice to remark upon a few striking points. Mr. Newton considers that Mr. Lydekker is most probably correct in referring the teeth of *Hyæna* from the Red Crag Nodule-bed to the existing *H. striata*; and a right lower canine from Felixstow is now provisionally added to the evidence of the species. Owen's determination of the common Wolf from the Red Crag Nodule-bed is also confirmed, while an upper premolar and two canines are additional specimens recorded. *Canis primigenius*, Mr. Newton thinks, may be founded on a Cetacean tooth. The occurrence of *Cervulus dicranoceros*, first determined by Sir Richard Owen and since questioned by Dawkins and Lydekker, is now admitted from new evidence; and the discovery of *Cervus elaphus* and *Cervus etueriarum* in the Forest Bed is definitely confirmed. Mr. Newton well remarks that "of two uncertain names it seems best to keep the one which has been so long in use, rather than introduce another equally uncertain;" and he thus describes the larger teeth of pigs from the Red Crag as *Sus antiquus*? Kaup. *Hipparion* is known only from the Red Crag Nodule-bed; and while agreeing with Mr. Lydekker that most of the teeth of *Rhinoceros* from this horizon may best be assigned to *R. incisivus*, the author considers that some may still belong to *R. Schleiermacheri*. *Elephas meridionalis* is definitely known from the Red Crag Nodule-bed, but *Elephas antiquus* has not been obtained below the Norwich Crag. There is still no evidence of *Mastodon* in the Forest Bed Series. To be "fashionable" Mr. Newton adopts the name *Microtus*, which literary "research" has lately shown to be applicable to the Voles; but "*Arvicola*" is placed in brackets to explain what is meant. The Cetacean remains from the Crag are treated in accordance with Mr. Lydekker's determinations; and the so-called tooth of *Ursus arvernensis* described by Lankester is ascribed to *Squalodon*. A vertebra and tooth of *Orca gladiator* from the Forest Bed are new, and another vertebra from the same horizon is referred to *Pseudorca*. The fish-remains are very fragmentary, but numerous, and the description of several distinct otoliths of *Gadus* is interesting. One tooth from the Coralline Crag is ascribed to the Wolf-fish (*Anarrhichas lupus*); and the occurrence of *Thynnus scaldiensis*, also in the Coralline Crag, is confirmed.

A tabulated list of species and a general summary conclude the Memoir. Notwithstanding the fragmentary character of all the remains, Mr. Newton's most painstaking researches have invested this summary with great interest and value. "It seems from a consideration of the Pliocene Vertebrata that the climate of England in the earlier part of that period was decidedly warmer than it is at the present day, and approached sub-tropical conditions; and that, notwithstanding minor variations which may have subsequently taken place, the general tendency was to become colder, so that in the Forest-bed times the climate was temperate, with, possibly, periods of greater heat and still greater cold, perhaps partly due to continental conditions, which at length culminated in the Glacial or Pleistocene Epoch. The earliest Pleistocene deposit recognized being the 'Arctic Freshwater Bed' of Norfolk, which is characterized by an assemblage of Arctic plants, and a *Spermophilus*, and occurs immediately below the Boulder Clay."

THE GEOLOGICAL SOCIETY.—The Medals and Funds to be given at the Anniversary Meeting of the Geological Society on February 19 have been awarded as follows:—The Wollaston Medal to Baron Ferdinand von Richthofen; the Murchison Medal to Professor A. H. Green, F.R.S.; and the Lyell Medal to Mr. George H. Moreton. The balance of the proceeds of the Wollaston Fund to Mr. O. A. Derby; that of the Murchison Fund to Mr. Beeby Thompson; that of the Lyell Fund to Mr. E. A. Walford and Mr. J. W. Gregory, and a portion of the Barlow-Jameson Fund to Prof. C. Mayer-Eymar.

III.—On the Formation of the Principal Groups of Iron-ore Deposits Occurring in Norway and Sweden. By J. H. L. Vogt. Transactions of the Geological Society in Stockholm, No. 138, Vol. 13, Part 5, May, 1891, pp. 476–536, Pl. 8.

Om Dannelsen af de vigtigste in Norge og Sverige representerede grupper af jernmalmforekomster af J. H. L. Vogt. Geologiska Föreningens i Stockholm Förhandlingar, Band XIII. Maj, 1891, s. 476.

THE author of this valuable communication has, in his work on slags, paid special attention to the conditions under which the silicates and other minerals are developed in magmas of varying composition. He is now extending the principles established by this kind of work to the igneous rocks of volcanic and plutonic origin. In the paper under review he deals especially with the origin of iron-ores of the Ekersund-Taberg type. These he attributes to "magmatic concentration" in strongly basic eruptive rocks; and in discussing the question of concentration he necessarily deals with matters of general interest to all students of igneous phenomena. Many of the facts referred to by the author have been described by previous observers, but they have never been grouped together so as to illustrate a general theory. Under these circumstances a somewhat extended notice of his paper appears to be thoroughly justifiable.

The author commences by remarking that ore-deposits may be divided into very well marked groups by taking into consideration the genetic principle which has been shown to be of so much value for classificatory purposes in other departments of natural science; and, after a general review of the principal Norwegian occurrences suggests the following classification:—

I. Ores formed by magmatic concentration in strongly basic igneous rocks.
II. Ores formed by pneumatolytic processes [*i.e.* a kind of subterranean fumarole-action; *e.g.* tin-stone deposits of Cornwall].[1]
III. Ores formed by sedimentation.
IV. Ores formed by metasomatic processes [*e.g.* Cleveland ironstone].
V. Ores formed by deposition of ferrous carbonate and other minerals in cracks.

In the consolidation of igneous magmas the ores and accessory minerals—magnetite, ilmenite, hematite, pyrite, magnetic pyrites, apatite, zircon, spinelle, titanite, perowskite, etc.—are first formed. Then follow the ferro-magnesian silicates—olivine, mica, pyroxene, amphibole—and lastly the minerals of the felspar group and free quartz. There may be a certain amount of overlapping in the minerals of the last two groups; but in a general way the order is that indicated above. Now the ore-deposits with which the author is immediately concerned can be accounted for by supposing that the chemical compounds of which they are composed became concentrated by diffusion-processes which are imperfectly understood at present. According to this view they would be analogous to the "basic patches" common in many eruptive rocks.

---

[1] The remarks in square brackets are interpolated by the reviewer. In what follows the author deals exclusively with the ores belonging to the first group.

As illustrating, in a general way, the effects of such diffusion, a dyke, 10 metres wide, occurring near Huk, in the Christiania district, is described. The centre of the dyke is a mica-syenite-porphyry, consisting of large crystals of orthoclase lying in a light red, fine-grained ground-mass. About one or two metres from the junction the ground-mass takes on a grey colour due to increase in the magnetite. As the junction is approached, the felspars decrease in size, plagioclase takes the place of orthoclase, and the ground-mass becomes darker and more compact. The actual margin is formed of a black rock, rich in iron, and containing a few porphyritic crystals of felspar (plagioclase) and mica. Pyrite increases as the junction is approached. The microscope shows that magnetite and biotite are very abundant in the marginal rock, which may be described as a kersantite. Chemical analysis establishes the fact that phosphoric acid is also more abundant at the margin than in the centre. The amount found corresponds to ·51 per cent. of apatite in the centre and 1·44 per cent. at the margin. There is nothing in the appearance of the dyke to suggest that there have been two intrusions. The transition from one type of rock to the other is gradual, and can only be accounted for by supposing that the magma became differentiated, before consolidation, by a concentration at the margin of the chemical compounds of the first formed constituents.

This case is so interesting that we quote below (1) the composition of the original magma as reckoned from actual analyses; (2) the composition of the centre; and (3) the composition of the margin:

SiO_2	62	63	47
Al_2O_3	17·5	17	20
Fe_2O_3	3	2·5	7·5
FeO			5
MgO	3	2·75	5·5
CaO	3·5	3	7·5
Na_2O	5	5·5	4
K_2O	4	4·5	1
FeS_2	1	1	3

Having illustrated in this way the general principles of magmatic concentration, the author describes in detail the ilmenite-deposits of the Ekersund-Soggendal district. They are found in a region composed of plutonic rocks which may be grouped under the following terms:—labradorite-rock (a norite extremely poor in ores and ferro-magnesian constituents), hypersthene-norite, biotite-norite and enstatite-granite. Dykes (exclusive of the ore-deposits) traverse the district. They may be classified, in the order of their formation, as follows:—

I. Ilmenite-hypersthene-labradorite dykes of pegmatitic character.
II. Norite dykes.
III. Diabase dykes, generally containing olivine.

Titanite is absent from the labradorite-rock and the true norites, but is found in the enstatite-granite. All the above rocks evidently belong to the same general period. They are the products of the consolidation of one magma-basin.

The ilmenite-deposit of Storgangen may be regarded as forming a dyke 3 kilometres long, and 20 to 70 metres wide. It consists of ilmenite, hypersthene and labradorite; and is, in fact, an ilmenite-norite. The average of ilmenite in the whole dyke is estimated at 40 per cent. In places as much as 70 or 80 per cent. may be found. The dyke is separated from the labradorite-rock by sharp boundaries. The same type of rock is found in several other portions of the norite-district; sometimes with lower and sometimes with higher percentages of ilmenite. As a rule it occurs under the same conditions as at Storgangen, and rarely passes over by gradual stages into labradorite-rock. In the true ore-deposits (Bläfjeld) the ilmenite predominates to such an extent that the rock loses its norite character altogether, and consists of 90 per cent. or even 95 per cent. of iron-ore. It occurs as dykes from two to six metres thick, and from one to two hundred metres long. Sharp fragments of the labradorite-rock occur as inclusions in the mass of the ore, thus proving conclusively that the veins are of later date than the surrounding rocks. Transitions may be observed between the ore-deposits and the pegmatitic dykes above referred to. The author gives several analyses of the ore, one of which we quote.

ORE FROM KYLAND.

SiO_2	44·05
Fe_2O_3	18·71
FeO	34·17
MgO	3·04
Total	99·97

A certain amount of magnesia is always found. This accords with the view that the formation of a magma, extremely rich in magnesia, is an intermediate stage in the formation of iron-ores by the process of concentration. The dykes of olivine-diabase and norite cut the ore-deposits.

Apatite is lowest in the labradorite-rock, somewhat more abundant in the ilmenite-norite (·05 per cent.), and reaches its maximum (5 per cent.) in the dykes of norite and olivine-diabase.

The ore-deposits of Taberg, in Småland (Sweden), described by Sjögren and Törnebohm, consist of titano-magnetite with olivine, traces of biotite, and a strongly basic felspar. The last-mentioned constituents are entirely absent from the richest ores. The mode of occurrence is different from that of Ekersund. The ore in this case is found *in the centre of a mass of olivine-hyperite into which it passes by insensible gradations.* The area occupied by the olivine-hyperite and the magnetite-olivinite (ore-deposit) is elliptical in form, and measures about one mile, by rather less than one-third of a mile. Similar rocks occur in other localities in Sweden and Dr. Wadsworth has shown that the ore of Rhode Island is of the same character.

That ore-deposits of the above type are the result of concentration in plutonic magmas is indicated by the following facts:—

(1) The different ores stand petrographically related to the surrounding rocks (*e.g.* magnetite-olivinite to olivine-hyperite and ilmenite-norite to labradorite rock).

(2) The ore in many cases passes gradually into the surrounding rock.

(3) In no case is there any evidence of the introduction of material by solutions or pneumatolytic processes. The segregations are characterized by the minerals of the surrounding rocks, and by these alone.

The author next proceeds to consider the main facts relating to concentration without reference to the causes which may have produced it, or to the chemical and physical conditions under which it has taken place. The iron oxides (ilmenite and titano-magnetite), which are the first minerals to form, are those which are most strongly concentrated. The ferro-magnesian compounds have also been concentrated, but not to the same extent.

The original magma of the labradorite rock of the Ekersund district may be supposed to have consisted of 2 parts ilmenite, 4 parts hypersthene and 94 parts labradorite; at a later stage of 6 Il. + 8 Hyp. + 86 La.; later still of 18 Il. + 16 Hyp. + 66 La.; again later of 40 Il. + 35 Hyp. + 25 La.; and lastly of from 80 to 95 or even 99 °/₀ of ilmenite, the remainder being hypersthene and labradorite. Similar phenomena are illustrated at Taberg and in the dyke at Huk.

Titanic acid is concentrated along with the iron oxides and enters into composition with them in the case of the segregations in basic eruptives. It is interesting to notice that in the Ekersund deposits the ore is ilmenite ($RTiO_3nFe_2O_3$ whence $R = Mg, Fe, Mn$), which may be regarded as formed in part of a metatitanate; in the more strongly basic rocks of Taberg it is titano-magnetite ($Fe_2TiO_4 nFe_3O_4$), which contains an ortho-titanate. In the former case the associated ferro-magnesian silicate is hypersthene, a metasilicate, and in the latter case it is olivine, an orthosilicate. In more acid magmas the titanic acid determines the formation of sphene, and the iron-ores if present are comparatively free from this constituent. In facts of this kind we see the influence of mass in modifying the chemical affinities.

Chrome-oxide, if present, is concentrated along with the basic minerals. The ilmenite of Ekersund contains chromium, and a little chrome-spinelle is found in the ilmenite-norite. Manganese is concentrated, but not to the same extent as iron.

Phosphoric acid may be concentrated; but not according to the same laws as iron, for it is more abundant in the dykes of diabase and norite than in the ore-deposits.

The position in the eruptive mass in which the rocks formed by concentration-processes are to be found is not the same in all cases. In the case of the dyke at Huk the basic parts form the margins; in the Taberg district the ore occupies a central position in the area formed of eruptive rocks; in the Ekersund occurrences it forms dyke-like masses which are sharply separated from the country rock.

The concluding part of the paper is occupied by a discussion of the processes by which concentration may have been brought about. Three ways are possible:—1. The minerals may be formed and mechanically collected in certain parts of the mother liquor. 2. The minerals may be formed and again dissolved in some other locality, thus producing a basic magma. 3. Concentration may take place by molecular diffusion without the actual separation of minerals.

The author considers that the first two methods have not been concerned in the production of the concentration which has given rise to the Ekersund deposits, for microscopic examination shows that the minerals have been developed *in situ*—not mechanically collected—and there are no corroded grains such as might be expected if the second cause had operated. We are therefore limited to the third method.

The homogeneity of a solution may be destroyed by temperature-differences and by gravity. The influence of the former has been experimentally established by Soret, and follows as a necessary consequence of Van 't Hoff's theorem that osmotic pressure in the case of dilute solutions obeys the laws of gaseous pressure. The influence of the latter has been deduced experimentally by Gouy and Chapéron from the laws of thermo-dynamics. Where solutions become heavier by concentration, the lower part will be more concentrated than the upper part. The difference is slight, and can only be recognized with difficulty when a tube 100 metres high is used. The specific gravity of a molten magma will increase with an increase in the number of molecules of magnetite, ilmenite, magnesia-iron-silicates, pyrite, etc. Hence these molecules will, according to the law of Gouy and Chapéron, be more abundant in the lower than in the upper portion of a magma-basin.

Differences of temperature operating according to what the reviewer has elsewhere termed Soret's principle will cause the same molecules to accumulate in the colder portions of the same magma-basin.

Another cause which is believed by the author to be effective in aiding concentration is magnetic attraction. The different iron-compounds when dissolved in silicate magmas are, doubtless, paramagnetic. Under the influence of the earth's magnetism the molecules may become orientated; but, so long as they are uniformly distributed throughout the mass, there can be no concentration due to magnetic attraction. If, however, owing to temperature-differences, or to gravity, a local accumulation of magnetic molecules takes place, the magnetic attraction may cause the concentration to become more and more pronounced.

The dyke at Huk furnishes an excellent illustration of concentration due to differences of temperature. The magma of the ore-deposits of Ekersund and Taberg must, however, have been formed by concentration in the deeper portions of a magma-basin. A certain influence may be ascribed to gravity acting on the specifically heavier molecules; but it seems hardly probable that the important results which have been observed can be due to this action alone Magnetic attraction operating constantly and for long periods may however, when taken in connection with gravity, have given rise to the necessary amount of concentration.

The high specific gravity of the earth may be due to the concentration of the heavier molecules in the central parts, by the causes above referred to, during the earlier stages of the history of the planet. If so, the ore-deposits under consideration are the genetic equivalents of the originally molten kernel of the globe.

The intimate relation between the ore-deposits and meteorites has been especially commented upon by Wadsworth. J. J. H. T.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—Dec. 23, 1891.—W. H. Hudleston, Esq., M.A., F.R.S., Vice-President, in the Chair.—The following communications were read:

1. "On Part of the Pelvis of *Polacanthus*." By R. Lydekker, Esq., B.A., F.G.S.

The specimen described in this paper was acquired by the British Museum from the collection of the late Mr. Beckles, and is from the Wealden, probably of the Isle of Wight. It is the central part of a Dinosaurian ilium, with portions of sacral ribs attached.

The point of special interest is a flat plate of bone, evidently a portion of dermal armour, resting on the upper border of the ilium; and this suggests comparison of the specimen with the dorsal shield of *Polacanthus Foxii*. Such a comparison shows that the present specimen belonged to a Dinosaur closely allied to, if not identical with, *P. Foxii*.

2. "On the Gravels on the South of the Thames from Guildford to Newbury." By Horace W. Monckton, Esq., F.G.S.

The author stated that the greater part of the hill-gravel in the district referred to belonged to the Southern Drift of Prof. Prestwich, and that the valley-gravels for the most part consisted of material derived from the Southern Drift. Small patches of Westleton Shingle and Glacial Gravel occurred near Reading and Twyford.

He divided the Southern Drift into three classes:—

1. Upper Hale type, characterized by the abundance of small quartz pebbles and the scarcity of chert.
2. Chobham Ridges type, with abundance both of small quartz pebbles and chert.
3. Silchester type; quartz scarce, and chert very rare or altogether absent.

He described the localities at which these types occurred and their limits of distribution, and then referred to the Glacial Gravels of the Tilehurst plateau, which he believed to have been deposited before the excavation of the valley of the Thames between Reading and Goring.

The author then dealt with the valley-gravels, which he believed to be mainly derived from the hill-gravels of the immediate neighbourhood, and showed how the various types of hill-gravel had contributed materials for the valley-gravels. He explained that, with the possible exception of the Westleton Shingle, he entirely rejected the theory of marine action in connexion with the formation of these gravels, and thought that the Glacial Gravels were probably for the most part due to floods during melting of large quantities of ice. The remaining gravels, he believed, had been spread out by water in valleys; as denudation proceeded, the gravel, by protecting the ground upon which it lay, came to stand out as the capping of the plateaux and hills; as the gravel itself was denuded, the materials were carried to lower levels, forming new gravels; and this process has been repeated up to the present time. He explained that Prof. Rupert Jones and Dr. Irving had already adopted this theory in part, but that he differed from them in the entire exclusion of marine action.

3. "The Bagshot Beds of Bagshot Heath." By Horace W. Monckton, Esq., F.G.S.

The author stated that certain changes in the classification of the Bagshot Beds had recently been proposed, and he gave reasons for preferring that at present in use, which was originally proposed by Prof. Prestwich in 1847, viz. a threefold division into Upper, Middle, and Lower Bagshot.

He then argued against the theory that the Upper and Middle Bagshot Beds overlap the Lower Bagshot on the north-western side of the Bagshot district, as had been suggested by Dr. A. Irving; and, dealing with the various localities where Upper Bagshot had been alleged to exist resting on Lower Bagshot or on London Clay, he contended that in every case the evidence in favour of Upper Bagshot age broke down on examination.

II.—Jan. 6, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., Vice-President, in the Chair.—The following communications were read:

1. "On a new Form of *Agelacrinites* (*Lepidodiscus Milleri*, n. sp.) from the Lower Carboniferous Limestone of Cumberland." By G. Sharman, Esq., and E. T. Newton, Esq., F.G.S.

Among a large series of fossils obtained during the Geological Survey of Cumberland and Northumberland, there are two which are referable to that remarkable and rare group of Echinoderms, the Agelacrinitidæ. The more perfect of these specimens is from the Lower Carboniferous rocks near Waterhead, on the River Irthing, and forms the subject of this communication. The disc-like fossil is only about four-tenths of an inch in diameter, and scarcely rises above the shell to which it is attached; nevertheless, it is so well preserved as to allow much of its structure to be studied. It is referred to the genus *Lepidodiscus*, and is seemingly closely related to *L. Lebouri*, described by Mr. Percy Sladen before this Society in 1879; but it also has affinities with *L. cincinnatiensis* and *L. squamosus*. From all these, however, the present specimen differs in having the pyramid in the middle of the interradial space, in possessing shorter arms, and in being much smaller. This fossil is to be named *Lepidodiscus Milleri*, after Mr. Hugh Miller, under whose direction these fossils were collected by Mr. J. Rhodes.

2. "The Geology of Barbados.—Part II. The Oceanic Deposits." By A. J. Jukes-Browne, Esq., B.A., F.G.S., and Prof. J. B. Harrison, M.A., F.G.S.

The Oceanic deposits rest unconformably on the Scotland Series, with which they contrast strongly in every respect. They are divisible into five portions:—

1. Gray and buff calcareous marls (Foraminiferal).
2. Fine-grained red and yellow argillaceous earths.

Pulverulent chalky earths (Foraminiferal).

4. **Siliceous earths (Radiolarian).**
5. **Calcareo-siliceous and chalky earths (Foraminiferal).**

The whole series is more calcareous in the northern than in the southern part of the island, and layers of volcanic dust occur in it at various horizons. There is everywhere a passage from the more siliceous to the more calcareous earths.

From the palæontological and lithological evidence the authors conclude that the depth of water in which the Oceanic beds were deposited varied between 1000 and 2500 fathoms. The microscopical and chemical evidence shows that the Radiolarian earths are similar to modern Radiolarian ooze; that the calcareo-siliceous earths are similar to what is called by Prof. Haeckel "mixed Radiolarian ooze"; that some of the Foraminiferal earths are comparable to *Globigerina*-ooze from 1000 fathoms, and that others greatly resemble European Chalk; and, finally, that the coloured clays bear a strong resemblance to the so-called "red clays" of modern oceanic areas. Hence the raised Oceanic deposits of Barbados seem to present us with an epitome of the various kinds of deposits which are found on floors of warm seas at the present day. Equivalent deposits are known in Trinidad and Jamaica; and it is inferred by the authors that the whole Central American and Caribbean region was deeply submerged during the Pliocene period, leaving free communication at that time between the Atlantic and Pacific Oceans.

An Appendix by Mr. W. Hill treats of the minute structure of the Oceanic earths and limestones and of the Foraminiferal muds and detritial earths; and this is supplemented by a Report from Miss Raisin on the inorganic material of certain Barbados rocks.

3. "*Archæopneustes abruptus*, a new Genus and Species of Echinoid from the Oceanic Series in Barbados." By J. W. Gregory, Esq., B.Sc., F.G.S.

This genus belongs to a group of Echinoidea which has given some trouble to systematists, owing to the union of the characters of the orders Cassiduloidea and Spatangoidea; the other genera belonging to the group are *Asterostoma*, *Pseudasterostoma*, and *Palæopneustes*. The evidence of the new Echinoid throws light upon the affinities of these genera. The main points suggested by a study of the new species are:—(1) the abandonment of the name *Pseudasterostoma* as a synonym of *Palæopneustes*; and (2) the inclusion of the true *Asterostoma*, *Palæopneustes*, and *Archæopneustes* in the Adete Spatangoidea, whereby the Plesiospatangidæ are left as a more homogeneous family, though bereft of the chief interest assigned to it.

A tabular summary of the nomenclature of the group is given.

The best-known fossil species of *Asterostoma* and *Palæopneustes* occur in Cuba, in deposits referred to the Cretaceous owing to the resemblance of these Echinoids to the common Chalk *Echinocorys scutatus*. The new genus includes a species from the same deposit, which is probably of the same age as the Bissex Hill rock from which the new species was obtained; this is at the top of the Oceanic Series, and belongs to the close of the great subsidence.

CORRESPONDENCE.

CRYSTALLINE SCHISTS OF THE LEPONTINE ALPS.

Sir,—Permit me to express my sincere regret to Dr. Stapff for having abbreviated not only his name but also—what is worse—his life. How the second misconception arose I cannot tell, but it is certainly not a recent one. Perhaps I ought also to apologize for not referring to his papers more frequently, but the truth is that I have only seen one of them, and that (for reasons on which it is needless to enter) I had but little opportunity of consulting. For this neglect some of my fellow-workers will probably visit me with censure. Be it so, I can only say that I do not always find myself quoted "over the water," and in this matter take as my maxim: *hanc veniam petimusque damusque vicissim.*

Except for this, my only purpose in writing, is to excuse myself from discussing at present Dr. Stapff's friendly and interesting communication. I am still at work on the subject of that singular complex of rocks in and about the Urserenthal, and cannot publish anything more till I have tested certain hypotheses on the ground. This I fear cannot be done during the present summer, since I anticipate that my steps must be turned in another direction, and I am not one of those fortunate persons who can undertake a long journey at pleasure in order to investigate a geological problem.

So I ask permission only to observe:—

(1). That I do not deny the possibility of Jurassic rocks or Carboniferous rocks entering into the complex of the Urserenthal. But I doubt the occurrence of organisms in the Altkirche marble. Without seeing the slides, it would be difficult to express an opinion on the nature of the objects figured by Dr. Stapff on page 18 of this volume; the upper one certainly has an organic aspect; the lower strikes me as more doubtful. But the nature of the objects is not the only thing to be considered.

(2.) That, if I am right in understanding Dr. Stapff to assign the Piora schists to the Carboniferous system, this identification appears to me only an hypothesis. If there be any valid evidence in favour of it, this is unknown to me, while I am aware of some serious difficulties in which we should be landed by accepting it.

(3.) That, from what I know of crystalline rocks and their ways, I venture to doubt the accuracy of the identification (p. 17) of "rolled quartz grains (*sand*) in some beds of the Guspis micaceous gneiss." For years I hunted for traces of an original clastic structure in gneisses and certain associated crystalline schists, longing to find them, but in vain. Again and again I have seen them curiously simulated here and there, by the results of pressure, and so, having been often taken in for a while, I have become rather sceptical.

T. G. Bonney.

CONCHOLOGICAL NOMENCLATURE.

Sir,—Mr. A. J. Jukes-Browne, in the January Number of the Geological Magazine, takes objection to some points in Conchological Nomenclature adopted in the "Systematic List of the F. E.

Edwards Collection of British Oligocene and Eocene Mollusca," to which I beg to offer the following remarks.

Mr. Jukes-Browne calls attention to the proposed disuse of *Cytherea* and *Triton*; two generic names which the reviewer discussed when noticing my book in "Nature" of October 29th, 1891. In a subsequent issue of the same Journal (November 12th, 1891), Baron Osten Sacken advocated the retention of *Cytherea* because the earlier Dipteroid genus of the same name being a synonym, and therefore rendered obsolete, could, from his point of view, be retained for another group.

Evidently these writers have not consulted the literature dealing with the Molluscan genera under discussion, or they would have ascertained that Lamarck's *Cytherea* had been replaced by his earlier *Meretrix* by many competent authorities such as Dr. J. E. Gray in 1847 (Proc. Zool. Soc. p. 183), Deshayes in 1853 (Cat. Conchifera British Museum, p. 34), H. and A. Adams in 1857 (Genera, p. 423), and other specialists, including Dr. Paul Fischer, who, in the latest and most elaborate treatise (Manuel, 1887, p. 1079) on the Mollusca, fully adopts it.

Concerning the name of *Triton*, we find that it has been used for three separate organisms: by Linnæus for a Cirripede in 1767; for an Amphibian by Laurenti in 1768; and for a Mollusk by De Montfort in 1810.

Writers on the Reptilia have ceased to regard it as one of their genera, because the Linnæan name has priority, and they have substituted *Molge* for it, a genus founded by Merrem in 1820. On the same grounds Malacologists also refuse to acknowledge it (as exemplified by the works of H. and A. Adams, Philippi, Weinkauff, Stoliczka, Zittel, Dall, etc.). Link's *Tritonium* of 1807 being the name now generally known for this shell, but as this differs from Müller's *Tritonium* of 1776, I have utilized the next most appropriate synonym, and brought into prominence Schumacher's *Lampusia* of 1817.

I hope this explanation will serve to show Mr. Jukes-Browne and others interested in this subject that the rejection of *Cytherea* and *Triton* as generic names in Zoology, being brought about through the operation of the law of priority, is now almost universally acknowledged.

R. BULLEN NEWTON.

BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD,
January 13th, 1892.

READE'S THEORY OF MOUNTAIN BUILDING.

SIR,—I read Mr. Jukes-Browne's criticisms of some points in my "Origin of Mountain Ranges"[1] with interest, and until I came to the Postscript, which, like a lady's letter, contains the most important part of the communication, contemplated replying to them. This last paragraph however being destructive of the need of the preceding criticisms puts another complexion on the matter.

Mr. Jukes-Browne must be aware that I have replied to Mr. Davison's arguments against the "expansion theory of Mountain evolution,"[1] and it appears unreasonable to expect me to discuss a fundamental principle at second hand, especially with the inadequate materials contained in the Postscript. Until Mr. Jukes-Browne has brought this central idea of Mr. Davison's, which he adopts, into harmony with his own ideas, it would be a waste of my time to traverse his criticisms, some of which present themselves to my mind as exceedingly immature. When this is done I shall be prepared to consider his arguments, and I must also ask him to be good enough to restate the first paragraph on page 28, as after re-reading I fail to understand it. His quantitative illustration is unfortunate as he has only exacted a tithe of what he is entitled to in my figures:—500×500×20 is not five hundred thousand, but five millions.

---

[1] GEOL. MAG. Jan. 1892, p. 24.

PARK CORNER, BLUNDELLSANDS, T. MELLARD READE.
Jan. 8, 1892.

OBITUARY.

HERR GEHEIMER BERGRATH
PROFESSOR DR. C. FERDINAND VON ROEMER,

FOREIGN MEMBER. GEOLOGICAL SOCIETY, LONDON.

BORN 5 JAN. 1818. DIED 14 DEC. 1891.

C. FERDINAND VON RÖMER was born at Hildersheim, in Hannover, in which kingdom his family occupied a position of some distinction, his father being a Councillor of the High Court of Justice, and his elder brother, Frederick Adolph, being a geologist of repute. Until the age of 18, Ferdinand Römer lived at Hildersheim and received his early education in the Evangelical Gymnasium of that town. In 1836 he removed to Göttingen, where he studied for four years, with the exception of a break of six months at Heidelberg: he had been enrolled as a student of the Faculty of Jurisprudence, but began to attend lectures in natural science, and soon became so interested in this subject as to entirely abandon his legal studies. In 1840 he proceeded to Berlin, and in 1842 the University of that city conferred upon him the degree of Ph.D. in appreciation of a palæontological thesis, "De Astartarum genere." Dr. Römer remained here for another three years, devoting his vacations to investigations on the older rocks of Western Germany. His main results upon this subject were published in 1844 in "Das rheinische Uebergangsgebirge." In the spring of 1845 he sailed for America; he made a very extensive tour through the States, and devoted a year and a half to the study of the geology of Texas, and especially of the Palæozoic and Cretaceous rocks of the western part of that State. He returned to Europe in November, 1847, and settled at Bonn, where he lived till 1855 as a "privat-docent," but occupied mainly in the elaboration and publication of the results of his American expedition. The most important of these was his "Die Kreidebildungen von Texas" (1852), which, with some smaller papers, have been recently described by Prof. Dumble,[2] the chief of the new Texan Geological Survey, as affording "a remarkably comprehensive view of the geology of the State."

---

[1] GEOL. MAG. June, 1891, p. 272.

[2] E. T. Dumble, Geol. Surv. Texas, Rep. State Geol. 1889, p. xxii. Austin, 1890.

In 1855 Römer accepted the Chair of Geology, Palæontology and Mineralogy in the University of Breslau; thenceforth his strictly geological work was mainly devoted to Silesia, his chief results being included in his "Geologie von Oberschlesien" issued as three quarto volumes in 1870. For this work he was knighted and appointed Geheim Bergrath of Silesia. But during the whole of this period he did not rest in peace at home: his travelling instincts, doubtless stimulated by his American experiences, repeatedly drove him to wider fields: thus in addition to tours in England, Belgium, Poland and Austria, he visited Sweden (1856); Norway (1859); Russia (1861); Turkey (1863); and Spain (1864 and 1871). In 1859 he was elected a Foreign Member of the Geological Society, by which he was also awarded the Murchison Medal in 1885. The later years of his life were spent at Breslau, busily engaged until the end, which came with sad suddenness just before the attainment of the jubilee of his doctorate; this his many friends and students were preparing to celebrate, out of respect for his high character and personal popularity, and in gratitude to his power as a teacher.

On turning to Ferdinand von Römer's work in science, one cannot but be impressed with his wide range of interests and knowledge: it seems doubtful whether he will be longest remembered as a geologist or palæontologist. In the former department he has added greatly to the knowledge of the stratigraphy of America and the countries that he visited; he worked at one time or another on nearly every system from the early Palæozoic to the Pleistocene; but probably his work on the Devonian rocks was the most important, ranging as it did right across Europe, from Devonshire to Constantinople. His palæontological works were very numerous and included papers on the Sponges, Graptolites, Rugosa, Ostracoda, Eurypterida, Arachnida, Bryozoa, Lamellibranchiata, Cephalopoda, all classes of Echinodermata; the Ophidia and Mammalia. Many of the genera he added to science were of exceptional interest, such as *Stephanocrinus* and *Dorycrinus*, while his discovery of the pinnules in Blastoids, and his work on the anatomy of *Cupressocrinus*, and the structure of *Melonites*, were important contributions to morphology. His monographs on the Asteroidea and Crinoidea of Bundenbach, on the Blastoids, and on the fauna of the Bone Caves of Ojcow, in Poland (of which an English translation was issued in 1884), and his "Die Fauna der silurischen Diluvialgeschiebe von Sadowitz," were all valuable additions to palæontological literature. His "Lethæa Palæozoica" issued between 1876 and 1880 as the first part of the third edition of the "Lethæa Geognostica" (with the early editions of which he had been associated) was a work of vast labour and permanent value. In later years Römer also wrote on mineralogy, issuing papers on the zinc ores, scheelite, columbite, and the pseudomorphism of cerrusite after cotunnite. But these three subjects did not exhaust his range of interests, for he was well read in literature both modern and classical, and his "Texas, mit besonderer

Rücksicht auf deutsche Auswanderung," showed his keen sympathy with the political and social problems of the time. J. W. G.

[As a friend and companion, Dr. Ferdinand Roemer was one of the most cheerful and congenial of men; the Editor is reminded of a delightful fortnight spent in his society in the Eifel, in 1878. His spirits and fun never seemed to become exhausted, and his vast stores of scientific knowledge were always at the disposal of his companions. His memory will be cherished by a large circle of younger men to whom his unvarying kindness will always be recalled with a sense of pleasing regret.—H. W.]

MISCELLANEOUS.

A MONUMENT TO WILLIAM SMITH, LL.D.

ONE of the most interesting historical collections preserved in the British Museum (Natural History) is the Geological Collection of William Smith, LL.D. This was commenced about the year 1787, and purchased by the Trustees in 1816, a supplemental Collection being added by Dr. Smith in 1818.

It is remarkable as the first attempt made to identify the various strata forming the solid crust of England and Wales by means of their fossil remains. There had been other and earlier Collections of fossils, but to William Smith is due the credit of being the first to show that each bed of Chalk or Sandstone, Limestone or Clay, is marked by its own special organisms, and that these can be relied upon as characteristic of such stratum, wherever it is met with, over very wide areas of country.

The fossils contained in this Cabinet were gathered together by William Smith in his journeys over all parts of England during thirty years, whilst occupied in his business as a Land Surveyor and Engineer, and were used to illustrate his works, "Strata Identified by Organized Fossils," with coloured plates (quarto, 1816; four parts only published); and his "Stratigraphical System of Organized Fossils" (quarto, 1817).

A coloured copy of his large Map, the first Geological Map of England and Wales, with a part of Scotland, commenced in 1812, and published in 1815—size 8 feet 9 inches by 6 feet 2 inches, engraved by John Cary—is exhibited in the Geological Department near his collection.

William Smith was born at Churchill, a village of Oxfordshire, in 1769; he was the son of a small farmer and mechanic, but his father died when he was only eight years old, leaving him to the care of his uncle, who acted as his guardian. William's uncle did not approve of the boy's habit of collecting stones ("pundibs"= *Terebratulæ*, and "quoit-stones"=*Clypeus sinuatus*); but seeing that his nephew was studious, he gave him a little money to buy books. By means of these he taught himself the rudiments of geometry and land-surveying, and at the age of eighteen he obtained employment as a land surveyor in Oxfordshire, Gloucestershire, and other parts, and had already begun carefully and systematically to collect fossils and to observe the structure of the rocks. In 1793 he was appointed to survey the course of the intended Somersetshire Coal-Canal, near Bath. For six years he was the resident engineer of the canal, and, applying his previously-acquired knowledge, he was enabled to prove that the strata from the New Red Marl (Trias) upwards followed each other in a regular and orderly succession, each bed being marked by its own characteristic fossils, and having a general tendency or "dip" to the south-east.

To verify his theory he travelled in subsequent years over the greater part of England and Wales, and made careful observations of the geological succession of the rocks, proving also, by the fossils obtained, the identity of the strata over very wide areas along their outcrops.

His knowledge of fossils advanced even further, for he discovered that those *in situ* retained their sharpness, whereas the same specimens derived from the drifts or gravel-deposits were usually rounded and water-worn, and had reached their present site by subsequent erosion of the parent-rock.

In 1799 William Smith circulated in MS. the order of succession of the strata and imbedded organic remains found in the vicinity of Bath.

His Geological Map of England and Wales is dated 1815.

On June 1, 1816, he published his "Strata Identified by Organized Fossils," with illustrations of the most characteristic specimens in each stratum (4to.).

In 1817 he printed "A Stratigraphical System of Organized Fossils," compiled from the original geological collection deposited in the British Museum (4to.).

In 1819 he published a reduction of his great Geological Map, together with several sections across England.

These sections have lately been presented to the British Museum by Wm. Topley, Esq., F.R.S., F.G.S., and are exhibited upon the wall near Smith's bust in the Geological Gallery (No. 11), see Guide-Book.

Mr. Smith received the award of the *first* Wollaston Medal and Fund in 1831, from the hands of Prof. Sedgwick, the President of the Geological Society—"As a great original discoverer in English geology, and especially for his having been the first, in this country, to discover and teach the identification of strata, and to determine their succession by means of their imbedded fossils."

In June, 1832, the Government of H.M. King William the Fourth awarded Mr. Smith a pension of £100 a year, but he only enjoyed it for seven years, as he died 28 August, 1839.

In 1835 the degree of LL.D. was conferred upon Mr. Smith by the Provost and Fellows of Trinity College, Dublin.

The highest compliment paid him was that by Sedgwick, who rightly named him "the Father of English Geology."

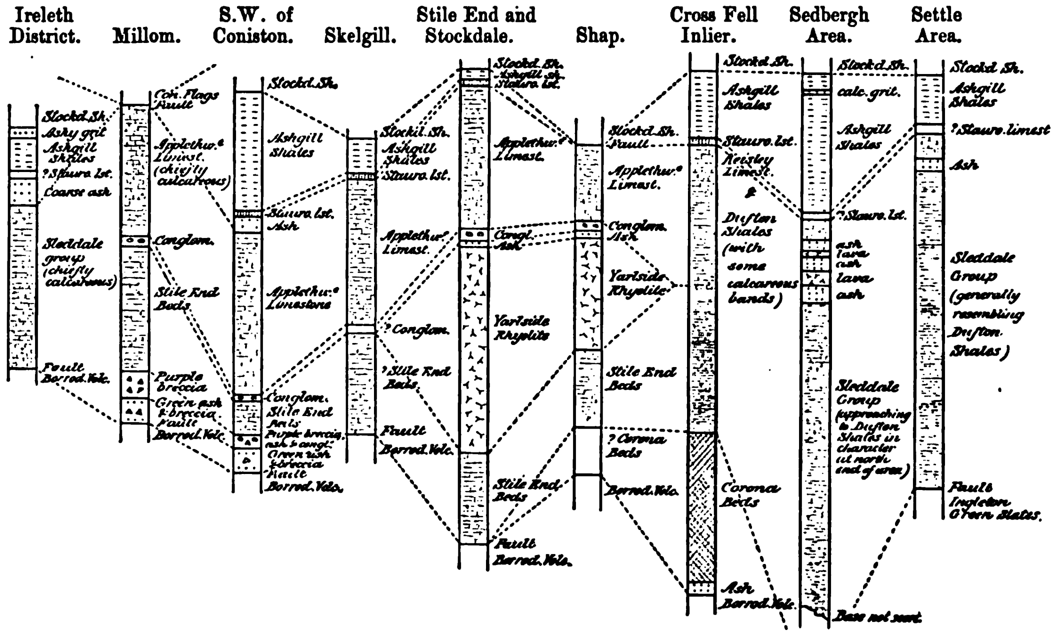
The bust above the case which contains William Smith's collection is a copy of that by Chantry surmounting the tablet to his memory in the beautiful antique church of All Saints, at Northampton, where his remains lie *buried.*

A monument has just been erected by the Earl of Ducie, F.R F.G.S., to the memory of William Smith, at Churchill, Oxfordshi where he was born; a village already famous as the birthplace Warren Hastings.

The monument is formed of huge Oolitic ragstones of the distr similar to the Rollright stones. The name "Oolite" was given William Smith to the rocks of the formation of which the hig grounds in this locality are a part.

This view of William Smith's Monument at Churchill has been prepared fro photograph taken by Lord Moreton, to whom we are indebted for permissio reproduce it here.

It is a monolith standing on a double base. The lower base 10½ feet square, and 3¼ feet high, the upper one is 6¼ feet squa and 2½ feet high. The monolith stands 9 feet high above t upper base, and is about 3 feet square. A marble slab is inser in the side facing the road from Chipping Norton, and bears t inscription:—"In Memory of William Smith, 'The Father of Brit *Geology'; Born* at Churchill, March 23rd, 1769; Died at Northam *ton, August 28th, 1839.* Erected by the Earl of Ducie, 1891."



Vertical Sections showing lateral changes in the Coniston Limestone Series.

A (?) after an unshaded portion indicates that the deposit named has not been seen at that place, but may be expected to occur.
A (?) after a shaded portion indicates a doubt as to whether the deposit belongs to the division of which the name is affixed.

Scale, about 1 inch to 125 feet.

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IX.

No. III.—MARCH, 1892.

ORIGINAL ARTICLES.

I.—The Coniston Limestone Series.

By J. E. Marr, M.A., F.R.S., Sec.G.S.

(PLATE III.)

It has long been known that the Coniston Limestone Series of the English Lake District and surrounding areas is separable into minor divisions. As a knowledge of these will prove useful in settling the question as to the exact relation between the Coniston Limestone beds and the underlying rocks, no apology seems needed for giving a detailed account of the rocks of this series.

The literature of the subject is extensive, but we fortunately possess an excellent bibliography of works referring to the geology of the Lake District, in the appendix supplied by Mr. Whitaker to the late Mr. Ward's Memoir on the Geology of the Northern Half of the English Lake District.

The main outcrop of the Coniston Limestone, as well known, is situated in a line running across the southern half of the district between Shap Wells and Millom, and here the series is succeeded by the Stockdale shales, and underlain by different members of the Borrodale Volcanic Series. Outlying patches occur in the Cross Fell area, the Sedbergh and Ingleton districts, and probably also in the extreme north of the Lake region.

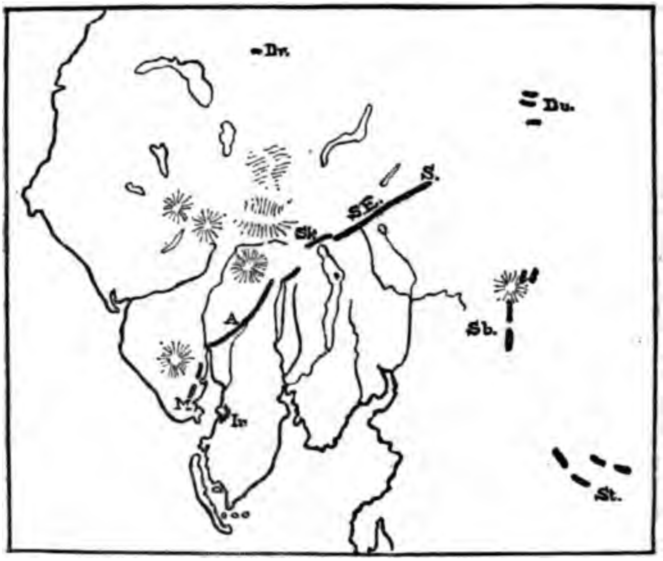
§ 1. *Classification of the Beds.*

Leaving out of consideration the doubtful beds immediately succeeding the rhyolites of Melmerby (cf. Nicholson and Marr, Q.J.G.S. vol. xlvii. p. 509), and which may possibly form the summit of the Llandeilo Series, the strata which form the subject of this communication belong to the Bala or Caradoc Series, and representatives of the whole of this period are probably present in the north of England. They may be classified as follows:—

Coniston Limestone Series.	Ashgill Group	Ashgill Shales, 50 feet. *Staurocephalus* Limestone, 5 feet.
	Sleddale Group	Applethwaite Beds, 100 feet. Conglomerate, 10 feet. Stile End Beds, 50 feet, with Yarlside Rhyolites above.
	Roman Fell Group	*Corona* Beds, 100 feet.

The figures indicate only approximate average thicknesses. The three groups are readily distinguishable by the characters of their faunas, that of the lowest group (Roman Fell), and of the highest (Ashgill), being quite different from that of the Sleddale group, which latter has yielded the greater number of fossils recorded in the Coniston Limestone lists hitherto published, though a few species belonging to the other two groups have been incorporated into these lists.

Outline-Map of the English Lake-District.



EXPLANATION OF MAP.

Scale 0 10 20 *Miles.*

Dr = Drygill.
Ir = Ireleth.
M = Millom
A = Ashgill.
Sk = Skelgill.

SE = Stile End.
S = Shap.
Du = Dufton.
Sb = Sedbergh.
St = Settle.

§ 2. *Detailed Description of the Sections.*—The fossils of the lowest (Roman Fell Group) have hitherto been detected only in the area of the Cross Fell Inlier, and the beds containing them have been recently described by Prof. Nicholson and myself in the paper referred to above. The thickness of the beds varies, and is difficult to measure owing to the disturbances which the rocks have undergone; but the greatest thickness probably does not exceed two hundred feet. The beds consist of ashes, ashy shales, and nodular black limestones, the latter often composed almost exclusively of the tests of *Beyrichia.* The table of fossils appended to this paper contains a list of the known forms from the beds of this group.

The other groups are well displayed in the tract of country between Shap Wells and Millom, and I propose to consider this tract first, commencing at the east end.

The most easterly section has been lately described (Harker and Marr, Q.J.G.S. vol. xlvii. p. 272). I would point out here that the limestone referred to the Stile End beds in that description may possibly be a member of the Roman Fell Group.

A considerable mass of fossiliferous ashy beds underlies the conglomerate near the Spa Well, and this mass may possibly represent the Stile End beds (the Yarlside rhyolite being here absent). The limestone above the waterfall at the head of the plantation presents lithologically a closer resemblance to the limestones of the Roman Fell Group than to the less pure limestones of the Stile End Group; but as no fossils have hitherto been recorded therein, the point must remain doubtful.

The lower limestone of the Wasdale Head section (Q.J.G.S. vol. xlvii. p. 271) is however, without doubt, the representative of that of Stile End, and lies immediately below the Yarlside rhyolite.

The section in Stockdale Beck is also given in our paper upon the Shap granite (p. 270). I would add a few words to the description given in that paper.

The Stile End Series is, as represented in our section, faulted against the rock of the underlying volcanic group. The evidence for this fault we hope to present in a future paper.

Above the nodular upper surface of the Yarlside rhyolite a thin band of ash is devoloped in Stockdale Beck.

The main mass of the conglomerate above this consists of subangular fragments chiefly of rhyolite, embedded in a slightly calcareous ashy matrix. The highest part of the conglomerate (well seen in Browgill) differs from this. It contains only a few pebbles which are mostly well-rounded, embedded in a tolerably fine calcareous matrix, and it passes up into the limestone of the Applethwaite Series, and is only separated from this series in the present communication on account of its importance as an easily recognizable horizon. The Ashgill Group is faulted out in Stockdale, but is seen in Browgill below the zone of *Diplograptus acuminatus.*

Few fossils have been obtained from the beds of this section; though fossils are abundant, they are indifferently preserved.

Crossing the valley of Long Sleddale, we find the Coniston Limestone Series well seen on the hills between that valley and Kentmere, especially near the farm of Stile End.

The Stile End beds are here quarried, and consist of grey-green calcareous ashes, weathering yellow, and containing abundant fossils, though these are badly preserved. We have identified:—

Lindstrœmia subduplicata, M'Coy.
Phacops, cf. *Eichwaldi*, Schmidt.
Orthis vespertilio, Sow.
—— *calligramma*, Dalen.

This list, meagre as it is, indicates the close palæontological relationship of the fauna of this series to that of the overlying Applethwaite Series.

The last exposure of the Yarlside rhyolite to the west occurs on the moorland above the Stile End beds, and in sections lying further west, the Applethwaite and Stile End beds are separated only by the conglomerate. The conglomerate has not been detected in the Stile End section, but the Applethwaite beds consist, as usual, of ashy calcareous shales, with bands and nodules of impure limestone. In the course of a small stream flowing towards Sleddale, and a little below the watershed, the *Staurocephalus* Limestone is seen faulted against the Skelgill beds of the Stockdale Shales, so that the Ashgill Shales are here cut out.

Many exposures of the Coniston Limestone Series are seen in the small valley running from the Garbourn Pass to Kentmere, occupied by the stream known as Hall Gill, and they contain abundant fossils, but the ground is much faulted, and it is difficult to make out the subdivisions.

On Applethwaite Common, also, the conglomerate has not been detected, and consequently it is impossible to assert positively that the representatives of the Stile End Group are present The Ashgill beds are found here, but their relationship to the Applethwaite series is not clearly shown. The beds of the latter series, as is well known, here contain abundant fossils. The highest beds of this series consist here of fairly pure limestones.

We now arrive at the important sections of the tract of country lying between Troutbeck and Windermere, the principal one being developed in Skelgill Beck and its tributaries.

Here, again, the conglomerate has not been seen, so that, although the beds seen in a quarry north-east of the 'Upper Bridge' over this stream strongly resemble the Stile End Beds, I am not prepared to assert that they belong to that series rather than to the Applethwaite series.

The beds of the Applethwaite Series consist mainly of calcareous, very fossiliferous, shales, with limestone bands, but a feature is here clearly seen, which probably characterizes also this series in the more obscure sections to the east. I refer to the existence of a white horny limestone at the very summit of the series. This is seen in the stream at the Upper Bridge, and the *Staurocephalus* limestone reposes directly upon it. No fossils have been extracted from this bed, but a number of large *Orthocerata* are seen in cross section in the bed of the beck. Such *Orthocerata* occur at Keisley, and it is possible that the Keisley limestone, which contains on the whole the fauna of the Applethwaite Limestone, along with some forms which are not known to occur nearer than the Chair of Kildare, is the highest subdivision of the Applethwaite Series. I wish to discuss this point at some length, because an important physical problem is connected with it. A similar limestone is found in Swindale Beck in the Cross Fell area, and was referred by Prof. Nicholson and myself to the *Staurocephalus* Limestone, on account of the occurrence of the fauna of that limestone in the associated calcareous shales. These shales, however, occur above the main mass of the Swindale Limestone, and on a re-examination of our specimens, I am inclined to think that the lower and purer part of the limestone of that beck, which contains large *Orthocerata*, like those of Skelgill, along with *Illænus Bowmanni*, may have to be separated from the upper part which has the true *Staurocephalus* Limestone fauna, and correlated with the Keisley Limestone; (a similar limestone occurs below the *Staurocephalus*-beds of Billy's Beck). If this be the case, the difficulty connected with the Keisley Limestone would vanish. It would occur under two conditions in the Cross Fell area, first, as a coarsely-crystalline very fossiliferous rock; secondly, as a horny limestone in which the fossils are mainly destroyed. Without offering here an explanation of the frequent occurrence side by side of these two conditions of a calcareous deposit, I may point out that they are very frequently found in disturbed regions. I would cite in our own country the Devonian rocks of the neighbourhood of Torquay, where the two varieties are found in the same quarry, also the "Knolls" described by Mr. Tiddeman (Report International Geological Congress of 1888, p. 319), which are found only amongst the rocks south of the Craven Fault, where there are evidences of great disturbance, and not in the nearly horizontal rocks to the north of the fault. Abroad, a similar case occurs in Bohemia in the Konieprus Limestone (F. f. 2). This limestone is generally a thin, horny, nearly unfossiliferous limestone, but in the "Knoll" of Konieprus, and Mnienian, we find the two varieties side by side. The same may be said of the *Leptæna* Limestone and Klingkalk of Dalecarlia (cf. Nathorst, Aft. ur Fören. i Stockholm Geol. Förhandl. No. 93, Bd. vii. p. 559), and the Devonian Limestone of the Ardennes.

It is not needful to discuss the origin of the nodular masses of crystalline limestone in this place. The cases cited show that the occurrence of the horny and crystalline conditions of the same limestone in immediate proximity is a common event, and therefore, whatsoever be the true explanation, there is nothing anomalous in referring the Keisley Limestone to the Applethwaite Group, though, as stated in the discussion on the paper by Prof. Nicholson and myself on the Cross Fell area, we only refer the Keisley Limestone and the Dufton Shales (which latter contain the ordinary Applethwaite fauna) to the same subdivision of the Coniston Limestone Series. If the suggestion thrown out above should prove to be correct, a further division of the Applethwaite Group may be made into a lower stage characterized by the ordinary Applethwaite fauna, and an upper stage characterized by the fauna of Keisley and the Chair of Kildare. This will probably be finally settled when the Irish beds are re-examined, and in the meantime I include the Keisley fossils and those of the other Applethwaite beds in one list.

The *Staurocephalus* Limestone of Skelgill is succeeded at the Upper Bridge by the Ashgill Shales, which are seen in a very fossiliferous condition on a small knoll by the roadside close to the bridge. The *Staurocephalus* Limestone is not very fossiliferous in

Skelgill; but on the moorland between this beck and Nanny Lane it has yielded a large number of fossils, especially *Cystideans.*

On the west side of Windermere an important development of the Coniston Limestone Series is seen in the neighbourhood of Sunny Brow. On Limestone Hill, to the west of Sunny Brow, a fell-road exposes an ashy calcareous grit with many casts of *Lindstrœmia*, faulted against the *Dimorphograptus* zone of the Skelgill beds. On the hill to the east of the road, and also in Cross Intake, normal Applethwaite Limestone is seen, with many corals. Although the conglomerate has not been detected here, the character of the ashy grit leaves little doubt that we are here dealing with the representative of the Stile End Beds, and this was the view taken by Professors Harkness and Nicholson in 1866 (Q.J.G.S. vol. xxiii. p. 482).

On the high moorland south-west of Coniston Lake, the Coniston Limestone Series is seen in numerous exposures, and the Applethwaite Series is extremely fossiliferous. Along this tract, as in the case of the Stockdale Shales, the cleavage is much stronger than in the district already traversed. The best section of the lower part of the series is shown at High Pike Haw, near the head of Appletreeworth Beck, whilst the upper portion is excellently displayed in Ashgill Quarry.

At High Pike Haw the discordance of strike between the Coniston Limestone Series and the underlying Borrodale volcanic rocks is excellently exhibited, as shown on the map of the Geological Survey. The lowest rock having the strike of the Coniston Limestone Series is a purple breccia associated with green ash. Above this are bedded ashy grits and conglomeratic beds, succeeded by a fossiliferous calcareous ash, strongly resembling the Stile End Beds. That it is actually referable to these beds is shown by the existence of a calcareous conglomerate above it, occupying the same position as at Shap and Stockdale. The conglomerate is succeeded by the Applethwaite Beds, which have a well-marked fine ash at the summit. The *Staurocephalus* Limestone is not seen here, though the Ashgill Shales come on above the Applethwaite group.

In Ashgill Quarry, the *Staurocephalus* Limestone is seen in the north-west corner, brought against the Skelgill Beds by a cross-fault. The Ashgill Shales form the main mass of the quarry, and are succeeded by the Skelgill Beds, in true sequence, at the top of the quarry-cliff. The relationship between the *Staurocephalus* Limestone and the Ashgill Shales above and Applethwaite Beds below, is also seen at one or two points in the course of Appletreeworth Beck.

The section at Millom generally resembles that at High Pike Haw. In Waterblean Quarries the lowest rock seen is a rhyolite of the Borrodale Series. Upon it rest green ashes and breccia, and then a purple breccia, as at High Pike Haw, but the fossiliferous Stile End Beds do not appear to be exposed in this quarry, although a remarkable development of beds, apparently referable to this stage, occurs in Millom Park, north of Beck Quarry, and striking so as to pass under the limestone of that quarry, and above the purple breccia which occurs to the west of this. These Millom Park Beds consist of ashy grits, and one pure quartzose grit, all crowded with fossils. At the base of the Applethwaite Limestone, both at Waterblean and in a small quarry south-west of Beck Quarry, we find the conglomerate, consisting of a calcareous ashy matrix, with the usual subangular fragments.

In Beck Quarry calcareous shales of ordinary character yielded the tail of a *Phacops* (*Chasmops*), but the greater part of this quarry, and of Waterblean Quarry, is excavated in a mass of crystalline limestone, white, except where stained pink by hæmatite, greatly disturbed, and resembling the Keisley Limestone in all particulars, save that it has unfortunately yielded no fossils hitherto.

On the east side of the Duddon Estuary, some interesting sections are displayed in the neighbourhood of Dalton and Ireleth. The rocks here are greatly disturbed. The lowest beds yet discovered belong to the Applethwaite Limestone subdivision, and rest sometimes on the Borrodale Beds, as near Ireleth, and to the west of High Haulme, sometimes upon the Skiddaw Slates, as in the neighbourhood of Crag Wood, west of High Haulme. Near Crag Wood the limestone is usually crystalline, as at Millom, and occurs in a series of remarkable knolls, surrounded by low ground, apparently occupied by shales. At the top of the Applethwaite Limestone we meet with a rock looking like a coarse breccia, succeeded by the Ashgill Group, so that it occupies the same position as the highest ash at High Pike Haw. It is seen in many exposures near High Haulme Farm, and its position is inserted on the Geological Survey Map. Its exact nature is doubtful. Normal Ashgill shales are found above it, and are seen in many exposures to the north of this, as far as Ireleth. Here the interesting section at Rebecca Hill shows the Ashgill Shales, containing in one place a thin band or nodule of much-crushed limestone, succeeded by a fossiliferous ashy deposit (also mapped by the Geological Surveyors), and separating the Ashgill Shales from the Stockdale Shales. That it appertains to the former is indicated by the interstratification of thin bands of shale, quite indistinguishable from the ordinary Ashgill Shales below. It would seem, therefore, that we have, in the Lake country, indications of volcanic activity throughout the whole period represented by the Coniston Limestone Series. Before leaving this part of the district, I may observe that the limestone of Tottlebank, south of the foot of Coniston Lake, which has sometimes been taken to be a continuation of the Coniston Limestone of the Ireleth region, is really on a much higher horizon, as indicated by the Geological Survey Map, and indeed belongs to the Lower Ludlow beds.

Turning to the outlying outcrops of the Coniston Limestone Series, I may revert to the Cross Fell area merely to remark that the Dufton Shales are the equivalents of the Sleddale Group as a whole, and that no conglomerate is found to separate them into Stile End and Applethwaite subdivisions, as has been done along the main outcrop.

Further details concerning the beds of this area will be found in the paper by Professor Nicholson and myself which has been alluded to previously.

The beds of the Sedbergh District are generally comparable with those of the Cross Fell inlier, *i.e.* the Sleddale Group assumes the facies of the Dufton Shales more closely than that of the region around Windermere and Coniston. The Calcareous Shales of Sally Beck south of Ravenstonedale are closely comparable with the Dufton Shales of Cross Fell. The *Staurocephalus* Limestone has not yet been detected in these regions, though the Ashgill Shales are developed in force; indeed the characteristic Brachiopod of these shales—*Strophomena siluriana*, Dav.—is figured in Mr. Davidson's Monograph from specimens obtained at Fairy Gill. In the centre of the Ashgill Shales a very calcareous grit is found (cf. Marr and Nicholson, Q.J.G.S. vol. xliv. p. 700), as seen at Backside Beck.[1]

The rocks of the Settle district have been referred to by me in a paper published in this MAGAZINE (Dec. III. Vol. IV. p. 35). The Applethwaite Group has the facies of the Dufton Shales, though a band of ashes is interstratified with the calcareous shales. The *Staurocephalus* Limestone has not been detected, though the Ashgill Shales are seen in the stream south of Wharfe, for I have found fossils of this age in the beds numbered "4. Blue, flaggy Brachiopod shales," in the paper referred to. Though the relationship of the Coniston Limestone Series to the representatives of the Stockdale Shales is perfectly clear in this neighbourhood, the true relations of the former to the Ingleton Green Slates is by no means clear. We have seen that in the central part of the Lake District the Coniston Limestone rests sometimes on the Skiddaw Slates, and not on the Borrodale rocks. Now the only reason why the Ingleton Green Slates have been referred to the Borrodale Series is because they are made up of volcanic detritus, and are immediately succeeded by the Coniston Limestone Series. As the latter fact does not prove their age, we can only point to the occurrence of volcanic detritus as a proof of the correctness of the correlation. The lithological resemblances, however, are very slight, and the volcanic detritus may be derived from rocks of any age. I am inclined to think that these Ingleton Green Slates may be older than any other beds hitherto recorded from the English Lake District, for there are grave difficulties in the way of correlating them with the Borrodale Volcanic Series.

---

[1] Since writing the above I have received the Survey Memoir of Quarter-Sheet 97 N.W. The contemporaneous volcanic series of Backside Beck and Wandale occurs at a higher horizon than that of any of the contemporaneous lavas hitherto detected in other parts of the district, with the possible exception of that running from Kentmere to Shap, and separating the Stile End Limestone from the Applethwaite Beds. It seems to occur high up in the Sleddale Group, and it will be remembered that contemporaneous volcanic ashes are found at the very summit of this group in the Coniston area. Mr. Strahan records the occurrence of a grit in the Ashgill Shales on a position corresponding to that of the above-mentioned calcareous grit, both in Taiths Gill and Birk's Field Gill.

The thickness of the Ashgill Shales recorded in Fairy Gill is exceptional.

The last area to which I have to refer is situated in the extreme north of the Lake District. Here a group of fossiliferous beds has been described by Professor Nicholson and myself as occurring at Drygill in the Caldbeck Fells (Geol. Mag. Dec. III. Vol. IV. p. 339). We were led "to refer the Drygill Shales to about the horizon of the Llandeilo Limestone, or to a slightly higher point in the series." Since then I have re-examined the fossils, and believe that two of them were wrongly identified (I may remark that I alone was responsible for this error). The *Calymene* recorded is more like *senaria* than *cambrensis*, and I cannot distinguish the *Trinucleus* from *T. concentricus*. The other fossils recorded are normal Caradoc fossils, and indeed, looking at the former list dispassionately, one would say that there was a preponderance of Caradoc forms, so that our reference of the deposits to the Llandeilo Series was no doubt influenced by its proximity to the Skiddaw Slates, for we remark that "they agree most nearly with the Dufton Shales as regards their fauna" . . . . though "from their general position between the Skiddaw Slates on the one hand and the lavas and ashes ('Eycott Series') of the Caldbeck Fells on the other hand, we should be led to conclude that they occupy a place low down in the latter series." As we have elsewhere seen that the Coniston Limestone is brought into contact with the Skiddaw Slates, the occurrence of Bala fossils near the Skiddaw Slates is not necessarily to be taken as an indication of the low position of the Drygill Shales, and looking at the fossils as a whole, I am disposed to refer the Drygill Shales to the Coniston Limestone Series, and not even to the lowest position of this, as the fauna is more closely comparable with that of the Dufton Shales than with that of the underlying *Corona* Beds.

Another argument in favour of the occurrence of a Coniston Limestone fauna on the north side of the district is the existence of *Cybele* near Cockermouth. Mr. Etheridge describes under the name of *Cybele ovata* a fossil found by Mr. Birkett, at Sandy Beck, near Wood (cf. Memoir by Rev. J. C. Ward, "The Geology of the Northern Part of the English Lake District," Appendix A, p. 112). Unfortunately, as I learn from Mr. Postlethwaite, the specimen was not found *in situ*, but occurred in a pebble; still, as this can hardly have been brought from the south side of the district, it probably indicates the existence of rocks with *Cybele* on the north side. Now this genus is not found in Britain below the Bala rocks, though it occurs at a lower horizon in Russia and Sweden. I have examined Mr. Birkett's specimen (now in the Keswick Museum), and it is very near to, if not identical with, *Cybele Loveni*, Linns., a common Coniston Limestone form.

§ 3. *Results of the Examination of the Series.*

The various equivalents of the Coniston Limestone Series have been discussed by myself and others in earlier communications, and it is only necessary here to give a general summary of the conclusions.

In the description of the Cross Fell Inlier by Professor Nicholson and myself, we compared the Roman Fell Beds with the *Beyrichia* Limestone of Scandinavia and the Trenton Limestone of North America, and suggested their correspondence with the Ardwell Beds of the Girvan area. The peculiar fauna will probably be discovered elsewhere, and should be searched for amongst the shales below the Bala Limestone of North Wales, and among the fossiliferous beds of Tyrone.

The well-known fauna of the Sleddale Group[1] has been so frequently and successfully compared with the similar fauna of the Bala Limestone, and its equivalents in the British and foreign Lower Palæozoic areas, that it is unnecessary to discuss the identity in this place, for it is now generally recognized. The relationship of the Dufton Shales to the *Trinucleus* Shales on the one hand, and the normal Sleddale Beds on the other, has also been commented on in a previous communication. The very abrupt change from the Lake District type of the Sleddale Group to the Cross Fell type in the short interval occupied by the newer beds of the Eden Valley, is a point that requires notice. I have already remarked on the likeness of the Keisley Limestone to that of the Chair of Kildare. A re-examination of the Bala Beds of Kildare and Tyrone is very desirable, as several stratigraphical horizons appear to be represented there, judging from the fossils which have been obtained.

The equivalents of the *Staurocephalus* Limestone occur in many parts of Britain, as well as in Scandinavia. Indeed, it is at first sight surprising to find how constant are the lithological characters of this green argillaceous limestone, when we remember that it is seldom more than a few feet in thickness. It retains its peculiar character in the south of Scotland (the "Starfish-bed), North Wales (*Rhiwlas* Limestone), Pembrokeshire (*Staurocephalus* Limestone), Ireland, and Scandinavia.

An examination of the fauna fully accounts for this constancy of character. Though it contains many species common to the overlying Ashgill Shales, there is a marked change betwixt the organisms of this limestone and those of the underlying Sleddale Group, and very few species are common to the two. Insignificant, therefore, as the thickness of this deposit is, the time taken for its accumulation was probably very great, and its characteristic organisms had time to become widely dispersed. The *Staurocephalus* fauna is far from being fully described, and few deposits would better repay a close examination by a local geologist. The most fossiliferous localities yet discovered in the north of England are the west corner of Ashgill Quarry, the moorland between Skelgill and Nanny Lane, Troutbeck, and, in the Cross Fell area, Swindale Beck and Billy's Beck. The Echinoderms and Crustacea of the bed are particularly remarkable.

---

[1] It may be remarked that sufficient proof has not been offered as to the distinctness of the Stile End Beds from the *Corona* Beds of the Cross Fell area. The somewhat meagre list of Stile End fossils previously given does not bring out the marked contrast between these beds and those of the Roman Fell Group. Not only is the peculiar fauna of the *Corona* Beds entirely absent from the Stile End deposit (and fossils, though ill-preserved and belonging to few species, are very abundant at Stile End), but the Stile End rocks are crowded with casts of *Lindstrœmia*, both in the region where the Yarlside rhyolite separates them from the Applethwaite Beds, and in the region further west. No *Lindstrœmia* has yet been detected in the Roman Fell Beds. In the neighbourhood of Coniston the Stile End Beds contain numerous fossils, which, as is usual with the beds of this series, are preserved as casts only, but fragments of several fossils generically identical with those of the Applethwaite Beds are easily discoverable, and, as far as one can judge, they are also specifically identical. Though it is just possible, therefore, that these Stile End Beds are actually representatives of the Roman Fell Group, all the evidence points to their being newer.

The overlying Ashgill Shales and their equivalents are fairly well known in those regions where there is a passage betwixt the Ordovician and Silurian strata. In Scotland we have similar shales above the starfish-bed in Lady Burn. In North Wales blue shales apparently referable to this horizon occur between the Bala Limestone and the Hirnant Limestone. In South Wales the Redhill beds contain a similar fauna, and occupy the same position. In Sweden the resemblance of the shales lying between the *Staurocephalus* Limestone and the representatives of the Stockdale Shales to our Ashgill Shales is very noticeable.

In North Wales the Hirnant Limestone is generally placed at the summit of the Ordovician beds, and Mr. T. Roberts and myself have also placed the Slade Beds of South Wales in a similar position. In Scandinavia, Tullberg assigns the lowest Graptolite-bearing stratum above the beds containing normal Bala fossils to the Ordovician system, on account of the absence of *Monograptus*. As it is succeeded by beds containing *Dimorphograptus*, it is probably the equivalent of the zone of *Diplograptus acuminatus* of the Birkhill (Skelgill) shales, and the same may be true of the Hirnant Limestone and the Slade Beds. The truth is that where we have an unbroken succession between Ordovician and Silurian rocks, the exact line of demarcation must be purely conventional.

In the table[1] (Plate III.) showing the variations of the different members of the Coniston Limestone Series, no attempt is made to give an exact representation of their actual thicknesses in various localities, for in the case of beds which have been so disturbed, such thicknesses, as taken by measurement on the ground, would probably be incorrect. Nor is this a matter of much importance in a case where volcanic outbursts are clearly seen to determine to a very large extent the changes of thickness, when the beds are traced along the outcrop. It is clear that in such cases, the position of former continental masses cannot be ascertained from a study of the direction of thinning out of the beds. The Ashgill Shales, however, do not show any great amount of volcanic material, but appear to be normal sediments. If the thickness assigned to these beds in Fairygill, in the Sedbergh district, be an approximation to their original thickness, this would show an expansion of these beds when traced eastwards, and this agrees with the observations made by Professor

---

[1] In this table, whilst the lava-flows and more prominent ashes are inserted, no attempt is made to indicate the finer volcanic material mixed with the Calcareous muds of many of the beds of the *Roman Fell* and Sleddale Groups.

Nicholson and myself in the case of the Stockdale Shales, which furnish much more precise data for accurate measurement. It is possible, therefore, that land lay to the south-east of the Lake District at the end of Ordovician and commencement of Silurian times, and this is supported by an examination of higher Silurian strata. The consideration of the beds above the Stockdale Shales must, however, be reserved for a future occasion.

§ 4. *Fossils of the Coniston Limestone Series.*

I. ROMAN FELL GROUP.

The smaller Crustacea are omitted in this list. They require revision.

Conchicolites gregarius, Nich.	Pusgill ; Roman Fell.
Ateleocystites, sp.	Roman Fell.
Homalonotus rudis, Salt.	Roman Fell.
Lingula tenuigranulata, M'Coy	Pusgill ; Roman Fell ; Swindale.
Strophomena grandis, Sow.	Swindale ; Pusgill.
Orthis testudinaria, Dalm.	Roman Fell.
Trematis corona, Salt.	Pusgill ; Harthwaite Beck ; Roman Fell.
Ambonychia gryphus, Portl.	Pusgill ; Roman Fell.
Bellerophon acutus, Sow.	Roman Fell.
—— *bilobatus*, Sow.	Pusgill ; Roman Fell.
Actinoceras pusgillensis, Foord	Roman Fell.
Cyrtoceras?	Roman Fell.

II. SLEDDALE GROUP.

The fossils from the Dufton Shales, and Keisley Limestone are included in the list. They will be recognized from the localities attached. The Corals are omitted, as the Coniston Limestone Corals are now being examined by Prof. Nicholson. Polyzoa also want revising.

Dicellograptus complanatus, Lapw.	Swindale.
—— *anceps*, Nich.	Norber ; Skelgill ?
Diplograptus socialis, Lapw. ?	Swindale.
—— *truncatus*, Lapw.	Hurning Lane, Dufton ; Norber.
Tentaculites anglicus, Salt.	Troutbeck ; Coniston ; Norber.
Ateleocystites, sp.	Norber ; Wharfe.
Acidaspis, n.sp.	Pusgill ; Applethwaite.
Amphion, n.sp.	Troutbeck.
Ampyx tetragonus, Ang.	Pusgill ; Billy's Beck.
—— *tumidus*, Forbes	Keisley.
Beyrichia complicata, Salt.	Applethwaite ; Coniston.
Calymene Blumenbachii, Brong. var. *Caractaci*, Salt.	Coniston ; above Rother Bridge.
—— *senaria*, Conr.	Horton ; High Haulme ; Coniston ; Applethwaite ; Swindale.
Cheirurus bimucronatus, Murch.	near Dent ; Keisley.
—— *cancrurus*, Salt.	Keisley.
—— *clavifrons*, Dalm. ?	Keisley.
Cybele Loveni, Linnrs.	Applethwaite ; Dufton ; Norber.
—— *verrucosa*, Dalm.	Ravenstonedale ; Helm Gill ; Swindale ; Pusgill ; Applethwaite ; Coniston.
Cyphaspis, cf. *triradiatus*, Törnq.	Keisley.
Cyphoniscus socialis, Salt.	Keisley.
Dindymene, n.sp.	Norber.
Encrinurus multiplicatus, Salt.	Barking ; Dent.
—— *multisegmentatus*, Portl. ?	Sunny Brow.
Harpes Doranni, Portl.	Coniston.
Homalonotus punctillosus, Törnq.	Keisley.
—— *Sedgwicki*, Salt.	Ravenstonedale.
Illænus Bowmanni, Salt.	Coniston ; Applethwaite ; Swindale.

Illænus cf. *conifrons*, Billings	Keisley.
—— *Davisii*, Salt.	Troutbeck; Wharfe.
—— *Rosenbergi*, Eichw.	Long Sleddale; Troutbeck; Sunny Brow.
Lichas laxatus, M'Coy	Pusgill; Keisley.
—— *laciniatus*, Dalm.	Coniston; Keisley.
Phacops Brongniartii, Portl.	Applethwaite; Coniston; Swindale; Backside Beck.
—— cf. *brevispina*, Schmidt	Coniston:
—— cf. *Eichwaldi*, Schmidt	Coniston; Applethwaite; Stile End.
—— (*Pterygometopus*) sp.	Norber.
Phillipsinella parabola, Barr.	Norber.
Primitia strangulata, Salt.	Applethwaite; Coniston.
Remopleurides Colbii, Portl.	Swindale; Applethwaite.
—— cf. *longicostatus*, Portl.	Keisley.
Sphærexochus boops, Salt.	Applethwaite; Coniston.
—— *calvus*, M'Coy	Keisley.
Trinucleus concentricus, Eaton	Pusgill. [Norber.
—— *seticornis*, His.	Applethwaite; Pusgill; Hurning Lane;
Turrilepas, sp.	Norber.
Youngia (Linnrs. non R. Jones) *trispinosa*, Nich. and Eth. jun.	Pusgill: Hurning Lane.
Atrypa expansa, Linnrs.	Keisley.
Leptæna transversalis, Dalm.	Coniston; Hilton Beck; Norber; Wharfe.
Lingula ovata, M'Coy	Coniston; Applethwaite.
Orthis Actoniæ, Sow.	High Haulme; Coniston; Applethwaite; Helm Gill; Keisley.
—— *bidens*, Salt., MS.	Helm Gill.
—— *biforata*, Schloth.	Ravenstonedale; Helm Gill; Troutbeck.
—— *calligramma*, Dalm.	Helm Gill; Troutbeck; Stile End.
—— *elegantula*, Dalm.	High Haulme; Helm Gill; Troutbeck.
—— *flabellulum*, Sow.	Applethwaite; Skelgill.
—— *insularis*, Eich.	Coniston; Troutbeck.
—— *porcata*, M'Coy	High Haulme; Helm Gill; Troutbeck;
—— *spiriferoides*, M'Coy	Troutbeck. [Keisley.
—— *testudinaria*, Dalm.	Pusgill; Harthwaite Beck; Keisley.
—— *vespertilio*, Sow.	Troutbeck; Coniston; Stile End; Dufton;
Strophomena corrugatella, Dav.	Keisley. [Keisley.
—— *deltoidea*, Conr.	Keisley.
—— *expansa*, Sow.	Keisley; Harthwaite Beck.
—— *pecten*, Linn.	Ravenstonedale; Troutbeck.
—— *rhomboidalis*, Wilck.	Helm Gill; Troutbeck; Coniston.
Loxonema obscura, Portl.	Keisley.
Cyrtoceras sonax, Salt.	Helm Gill.
Orthoceras, cf. *elongato-cinctum*, Portl.	Keisley.
Orthoceras velatum, Blake	?
Trochoceras cornu-arietis, Sow.	Troutbeck; Coniston.

IIIa. STAUROCEPHALUS LIMESTONE.

Echinosphærites arachnoideus, Forbes	Swindale.
—— *balthicus*, Eichw.	Troutbeck.
—— *Davisii*, M'Coy	Troutbeck.
—— *mammosus*, Salt. MS. ?	Troutbeck.
Agnostus trinodus, Salt. ?	Troutbeck.
Acidaspis	Swindale.
Calymene Blumenbachii, Brongn.	Ashgill.
Lichas laciniatus, Wahl.	Swindale.
Ogygia	Ashgill.
Phacops apiculatus, Salt.	Ashgill; Troutbeck.
—— *eucentra*, Ang.	Ashgill; Troutbeck.
—— *Jukesii*, Salt.	Swindale.
Phillipsinella parabola, Barr.	Swindale; Troutbeck.
Staurocephalus globiceps, Portl.	Troutbeck; Billy's Beck; Swindale.

Turrilepas	Ashgill; Troutbeck; Swindale.
Skenidium, n.sp.	Billy's Beck.
Holopea	Troutbeck.
Orthoceras vagans, Salt.	Troutbeck.

IIIb. Ashgill Shales.

Cornulites	Skelgill; Backside Beck.
Myelodactylus ?	Backside Beck.
Glyptocrinus	Skelgill.
Ogygia	Troutbeck.
Phacops apiculatus, Salt.	Rebecca Hill; Troutbeck.
—— *eucentra*, Ang.	Ashgill; Troutbeck.
Phyllopora Hisingeri, M'Coy	Backside Beck.
Orthis actoniæ, Sow.	Skelgill.
—— *biforata*, Schlot.	Skelgill; Ashgill; Swindale; Backside Beck.
—— *calligramma*, Dalm.	Skelgill.
—— *elegantula*, Dalm.	Skelgill; Swindale.
—— *protensa*, Sow.	Skelgill; Ashgill; Swindale; Backside Beck.
—— *testudinaria*, Dalm.	Skelgill; Applethwaite.
—— *vespertilio*, Sow.	Skelgill.
Strophomena siluriana, Dav.	Troutbeck; Skelgill; Ashgill; Rebecca Hill; Swindale; Fairy Gill; Backside Beck.
Theca triangularis, Portl.	Skelgill.
Bellerophon	Ashgill.

II.—REMARKS ON THE FORMATION OF LANDSCAPE MARBLE.

By HORACE B. WOODWARD, F.G.S.

THE Landscape Marble or Cotham Stone is one of the best known of our English ornamental rocks. Polished slabs of it may be seen in most museums; and there are fashioned out of it paper-weights, ring-stands, and other useful objects, which may be purchased on Clifton Down and elsewhere.

This stone came into notice when it was quarried, together with other beds, near Cotham House, on the northern side of Bristol; and it was described in considerable detail in 1754 by Edward Owen, who then gave it the name of "Cotham Stone."[1]

It is a hard, close-grained argillaceous limestone, which breaks with a fracture almost as conchoidal as that of flint; and it is characterized by dark arborescent markings which pervade the stone. These markings rise from a more or less stratified base, and terminate upwards in the wavy banded portion of the limestone, which varies from one to about nine inches in thickness. Thus when slabs, cut at right angles to the planes of bedding, are polished, there may often be discerned (with the aid of the imagination) a landscape with a prominent row of trees and bushes, with clouds above, and perhaps the semblance of water in the foreground.[2]

The lower surface of the limestone is even, though sometimes in small masses of the rock it is gently curved; the upper surface is corrugated, and the irregularities appear to correspond in many instances with the original planes of deposition, for thin layers that coincide with the uneven surface may be split from the rock. In other instances the ridges on the surface are curiously interlaced, forming a kind of "rustic work" that is prized for rockeries. It seems likely that the upper surface of the stone is largely due to the shrunken state of the calcareous mud from which the Cotham Stone originated. So far as I know, wherever the crinkly surfaces and the arborescent markings are present, the limestone occurs in isolated and lenticular masses; and these are sometimes less than a foot across, sometimes three feet or more. Where the stone, or its equivalent, occurs as a fairly persistent layer, it maintains its compact character, it is banded and evenly bedded, but the arborescent markings are wanting.

---

[1] Observations on the Earths, Rocks, Stones, and Minerals, for some miles about Bristol, etc., 8vo. London.

[2] An illustration of the Landscape Marble was published in the Proc. Geol. Assoc. vol. i. p. 209.

While the Cotham Stone is present in a number of localities from Bristol to Uplyme in Devonshire,[1] yet in many sections exposed over that area it has not been recognized or but doubtfully identified, partly because of its impersistent nature, and partly because it may be represented by a layer without arborescent markings. This is the case also in the country north of Bristol.

It is interesting to find that this layer of limestone extends, even in interrupted masses, over so large an area, and it is noteworthy that wherever the characteristic Landscape Marble has been observed, it occupies a position in the Rhætic Beds, at or near the junction of the Black *Avicula-contorta* Shales with the overlying beds of White Lias. The limestone thus forms an horizon of some service to the geological surveyor, and it may be tracked across many a ploughed field between Bath and the Mendip Hills. The finest examples of the stone that I have seen, were opened up during the construction of the Midland Railway between Bath and Kelston.

To its stratigraphical position the Cotham Stone may in some measure owe its peculiar characters, occupying as it does an intermediate place between dark argillaceous sediments and almost pure calcareous mud. In some localities a few inches of dark clay may be found above the Stone, but usually it is overlaid directly by the pale marls and limestones of the White Lias. It marks a stage when this calcareous sediment was commingled with a slight amount of dark mud deposited in occasional films. Thus an ordinary banded limestone was produced in many places, as seen in the railway-cutting at Cossington, between Bridgewater and Edington, at Aust, and at Lassington near Gloucester. Beds of this character, although they exhibit no arborescent markings, are often spoken of as "Cotham Marble," because they occupy the same stratigraphical position.

Between this ordinary banded limestone and the distinctly arborescent types, all sorts of intermediate varieties may be found; but as most of these varieties are not 'ornamental,' they are regarded as unsuitable for polishing, and do not come much into notice. Occasionally in less compact rocks, where darker and lighter layers of material are present, arborescent markings may be found; this is the case in the '*Estheria*-bed,' which occurs in the upper part of the

---

[1] See Dr. Wright, Geol. Mag. 1864, p. 291.

Rhætic Beds at Garden Cliff, Westbury-on-Severn; and it is an exceedingly irregular and nodular limestone.

In other formations I have met with similar phenomena. In the Lower Purbeck Beds at Durlston Bay, near Swanage, there is a thin layer of limestone that presents the same corrugated and mammillated surface as the Cotham Stone, and it exhibits obscure arborescent markings. Again at Rounden Wood near Battle, a layer presenting like characters, occurs also in the Purbeck Beds. In the same district near Battle, there is a bed of more or less nodular limestone called the 'Cutlets,' and this sometimes possesses curious irregular bands of light and dark grey tints, that form a sort of intermediate stage between even banded limestone and Landscape Marble. There is a specimen of this rock in the Museum at Jermyn Street.

Another illustration I have met with in the Inferior Oolite of Charlcombe, near Bath, where there occurs a bed of compact brown limestone, banded at the base like the Cotham Stone, and becoming nodular (and in this case also somewhat concretionary) above; and this rock exhibits faint resemblances to arborescent markings.

For want of a better explanation I have elsewhere compared the arborescent markings in the Landscape Marble with the dendritic *infiltrations* of manganese-ore, etc., so commonly met with on the surfaces of rocks, whether along joints or bedding-planes.[1] I now think there is no particular connexion between the phenomena of *infiltration* and the production of the Landscape Marble.

The ferruginous infiltrations that produce irregular bands of colour throughout the mass of many rocks, present no close resemblance to the features of Landscape Marble. Some of the appearances met with in the fissile limestone known as 'Florentine Slate' and 'Ruin Marble,' are due to infiltrations of oxide of iron that permeated the stone probably after consolidation; while the rock itself, thus irregularly banded, was subsequently fractured, and portions of it shifted by minute faults that have given the sharp outlines to the "ruins."

It may be mentioned that other beds of limestone above the Cotham Stone, and as high as the 'Sun Bed,' which is locally the top layer of the White Lias, occasionally present irregular and corrugated surfaces, but these occur in homogeneous limestone, and no arborescent markings are exhibited. The fact indirectly lends support to the view that the arborescent markings of the Cotham Stone are contemporaneous and not due to subsequent infiltration.

There is no evidence to support the notion that gaseous emanations, such as might have arisen from the black mud of the *Avicula contorta* Shales, had anything to do with the formation of the Landscape Marbles. This notion was to a certain extent suggested by E. Owen, who thought the arborescent markings were produced by the escape of imprisoned air; but had such agents been at work the markings would not be confined to the nodular masses of rock, and they would extend upwards through the base of the limestone.

It appears to me that the arborescent markings were produced

---

[1] Geol. E. Somerset, etc. (Geol. Survey), p. 70; and Geol. England and Wales, ed. 2, p. 244.

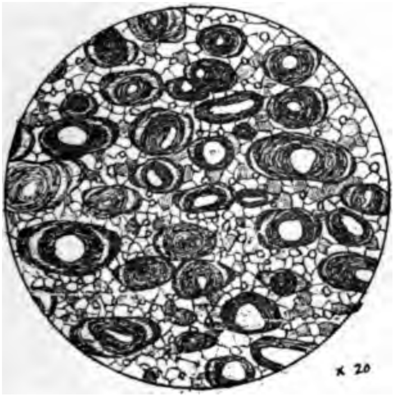


FIG. 1.—Section of Hirnant Limestone × 20.

The grains are made up of four layers—(1) Central nucleus of calcite. (2) Carbon. (3) "Chalcedonic" silica. (4) Outer bands of dusty material and carbon. (3) and (4) are sometimes repeated.

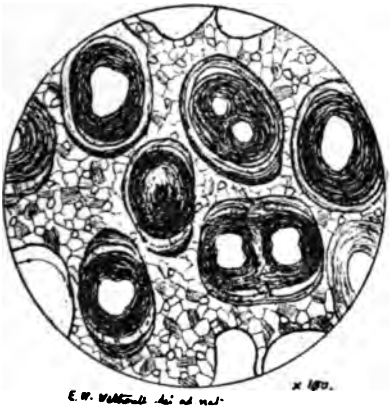


FIG. 2.—Section of Hirnant Limestone × 100.

To illustrate Mr. L. W. Fulcher's paper on the Composition and Structure of the Hirnant Limestone.
(p. 114.)

during the consolidation of the stone, and more particularly by the shrinking of its upper portions. In this way, and while the mud was still in a more or less pasty condition, one or more of the dark films in the banded mass were disarranged and dispersed in arborescent form in the slowly setting rock. The features displayed in different specimens of the Landscape Marble suggest that sometimes an upper and sometimes a lower film of dark mud was dispersed. There are specimens likewise that exhibit a double landscape, one above the other. An example is figured by E. Owen (*op. cit.* pl. i. p. 163), and similar specimens are preserved in the Museum of Practical Geology. In these instances there seems evidence of a prior consolidation in the rock, followed by more calcareous mud, the whole ultimately coalescing to form one layer of limestone. It may be that the production of the isolated masses of rock with their irregular upper surfaces, was attended by some pause in the deposition of sediment, and by exposure of the layer to the sun's rays. There is no doubt that such circumstances took place during the Rhætic period; and the rolled lumps of contemporaneous limestone met with in the White Lias near Lyme Regis and near Harbury are suggestive of such exposure during the later stages of the period.[1] Thin veins of calc-spar occasionally penetrate the 'inferior kinds' of Landscape Marble, and these fill cracks that were perhaps the final result of consolidation: the mass of the stone being sometimes found in a minutely faulted condition.

Under the microscope the dark arborescent portions appear sharply defined from the main mass of the Cotham Stone, and some tiny dark portions are seen to be isolated. Mr. J. J. H. Teall, who kindly examined the rock, states that it is "mainly composed of extremely fine granular calcite, and that it contains a few very small grains of quartz. In the part which shows the characteristic markings there are patches of clear and sometimes coarse-grained crystalline calcite." These facts are not inconsistent with the view that the appearances are due to the partial intermixing of the dark and light layers of mud during consolidation, albeit attended by some crystallization of calcite.

The evidence here brought forward is essentially stratigraphical; but if the suggested explanation be true, it serves to indicate the kind of re-arrangement that may take place when a pasty sedimentary mass solidifies in a somewhat irregular manner.

It has been noticed that the upper surface of the Cotham Stone is generally corrugated, but that it is sometimes formed of branching or interlacing ridges. These latter may be connected with phenomena of segregation. The segregation and concentration of calcareous material is shown in the irregular and nodular character of some of the Lias limestones, and in other formations where cement-stones and septaria occur. Some nodules of "race" and ironstone exhibit mammillated surfaces, when there is no evidence of concretionary action such as would be indicated by the deposition of successive coats of mineral matter.

---

[1] Proc. Geol. Assoc. vol. xi. p. xxx.

The process of formation of the Landscape Marble seems to me to have been mainly mechanical, although, as might be expected, there is evidence also of chemical change. In attributing the corrugated surfaces to the shrinking of the calcareous mud, I may have appealed too strongly to mechanical causes, as apart from the obscure processes of segregation, or even of concretionary action.

The facts, however, show the connexion between the arborescent markings and the corrugated and lenticular masses of banded limestone; and they support the contention that the markings were produced by changes amid the variously tinted calcareous mud during its solidification.

III.—NOTE ON THE COMPOSITION AND STRUCTURE OF THE HIRNANT LIMESTONE.

By L. W. FULCHER, B.Sc., F.C.S.

(PLATE IV.)

DURING the summer of 1890, Professor Cole and I, whilst geologising in North Wales, were led to examine the Hirnant Limestone. Since then the further examination in the laboratory of the specimens collected by myself have revealed some remarkable characteristics which, as they are as yet undescribed, I think are worthy of notice.

The specimens on which the following observations have been made were obtained from a small cutting opposite to the farm named Cwm-yr-aethnen, in the valley of the Hirnant, which descends towards Bala Lake. The limestone occurs here between two beds of fossiliferous slate. The exposure is very small, and being considerably overgrown, it was only by careful search that we succeeded in finding it. The Survey Memoir[1] mentions that an outcrop occurs at Trum-y-gwrageda, and also that loose blocks were found by Sedgwick at the Bwlch-y-groes; but after a careful search we failed to find it at either of these localities.

It is necessary for me to add here that I am greatly indebted to Prof. Cole for much valuable advice and criticism of the facts observed as well as for the loan of some material, and I hereby tender him my best thanks.

The rock is described in the Survey Memoir as "fossiliferous, black and pisolitic, the concretions being about the size of small grains of barley."

It is a very tough rock, and in hand specimens from the above-mentioned locality the black grains, which are mostly ellipsoidal in shape, are from 1 mm. to 3 mm. in their longest diameter, and are somewhat sparsely scattered in a crystalline matrix, that is to say, they are not so crowded together as in the case of an ordinary piece of oolite limestone. The centres of the grains often show the bright cleavage face of a calcite crystal.

An analysis of the rock reveals the interesting fact that the black-ness of the grains is due to *carbon* in an amorphous form. The following were the numbers obtained by a quantitative analysis:—

---

[1] Ramsay, Geology of North Wales, Mem. Geol. Survey, vol. iii.

Insoluble residue (other than carbon)	18·35
Carbon	1·18
SiO_2 (soluble)	·27
FeO	1·57
CaO	42·85
MgO	1·05
CO_2	34·15
P_2O_5	1·35
H_2SO_4	·06
	100·83

These figures correspond to a total percentage of $CaCO_3$=72·82, $MgCO_3$=2·2, and $FeCO_3$=2·43. It also gives off a trace of SH_2 when dissolved in hydrochloric acid. The insoluble residue (including the carbon) contains approximately carbon 7 per cent.; SiO_2 77 per cent.; and $Fe_2O_3 + Al_2O_3$ 11 per cent.; the remaining 5 per cent. containing lime, etc.

The specific gravity of the rock varies slightly in different specimens from the same locality. Thus two determinations kindly communicated to me by Prof. Cole gave 2·604 and 2·67, while another for which I am indebted to Mr. Hume gave 2·642. These differences are readily explained by the variation in composition of this rock, even at distances of a few inches in the same specimen, which is shown when sections are observed under the microscope. Reference is made to this further on.

When a piece of the rock is treated with dilute hydrochloric acid, the calcite is gradually dissolved and the grains are left as little black hollow ellipsoids, together with a quantity of fine sand and carbon in powder. These black grains, when pressed by the finger on a piece of paper, soil both the paper and the fingers just like soot would do. But they are not wholly composed of carbon; for on heating them to redness in a platinum capsule, they turn of a reddish-brown colour, still retaining their shape, though all the carbon has been burnt off. It is easily seen now by applying the usual tests that these residues are composed of silica coloured by a little oxide of iron. Some of the black grains mounted in Canada balsam show a concentric structure, but this is much better studied in sections of the rock itself.

Amongst the residue of a piece of the rock about 1½ inches square I also obtained some fragments of a very fine micaceous sandstone, the largest of which measured 11 × 8 mm. This particular fragment also had some very regular black markings on its surface, which I thought might possibly be leaf-scars; but on submitting the fragments to Mr. Boodle, this gentleman gave his opinion against this idea, but suggested that they might possibly be aggregations of fine sand around small vegetable filaments, as the carbon in the fragments seemed to occupy the hollows of very small canals. Of course this point cannot be settled until large quantities of the rock are dissolved, so that a good many of these fragments can be examined.

At present I have not the material for this purpose, but I have thought it well to mention the fact of the peculiar aspect of these sandstone fragments, as Ordovician plants are so rare that any indication of their existence is naturally a matter of interest. I may add that a section which I had prepared of the fragment did not reveal any noteworthy characters under the microscope.

When a section of the rock is examined under the microscope, we see the grains lying in a crystalline matrix of calcite (Pl. IV. Figs. 1–2, for the drawings of which I am indebted to the kindness of Mr. E. W. Wetherell). The centre of the grains consists usually of granular calcite, and in some cases has the form of a figure of 8, but is generally rather irregular in shape. Occasionally the nucleus is the fragment of an organism or a grain of sand. Around the centre the carbon appears as a series of opaque concentric rings, though now and then patches are seen to have been torn away in the preparation of the section. In a few cases the carbon seems to fill up the whole of the interior of the grain, but this is probably due to the fact that the centre of such grains has not been cut through. Externally the grains are seen to be increased in the direction of their longer axes by a secondary development of a fibrous-looking mineral. This statement, however, must be modified. In all the sections which I had prepared from my own specimens this secondary mineral appears; but Prof. Cole has lately lent me a slide in which it is entirely absent, so that the alteration is possibly only local. The fibrous-looking mineral from its optical properties seems to be a chalcedonic variety of silica. Under a high power the fibrous appearance is seen to be due to a number of thin elongated prisms which are apparently quartz. This mineral is itself bounded by a band of almost opaque material which sometimes includes carbon. There are often three or four bands of chalcedony separated from each other by a layer of the dusty material.

There is very rarely a radial grouping in the grains as in some Oolites, nor does there appear to be any such structure as the recentl described *Girvanella*.[1] The grains give no black cross betwee crossed Nicols.

The matrix in which the grains are embedded is seen to b ordinary crystalline limestone, but it contains here and there frag ments of organisms (Polyzoa), and also small irregular grains o quartz, which are by no means regularly dispersed, being in som places much more numerous than in others. These quartz grains ofte contain moving bubbles. It is also to be noticed that occasionall an extremely thin band of secondary calcite traverses the whol section, penetrating right through the grains. A section which ha been mounted in Canada balsam, and then etched with hydrochlori acid so as to dissolve the calcite before being covered up, shows mor clearly the concentric structure of the grains and the outer coatin of chalcedonic silica which they possess.

It will be observed from the above description that the rock i somewhat analogous in structure to the Cleveland iron ore,[2] th thampton iron ore,[1] and the pisolitic iron ore of Cader Idris.[2] It ers from all these, however, in the fact that the grains have a ting of carbon, and in the absence of the oxides of iron which n the chief constituent of the latter. It resembles all the above- itioned rocks in the fact that the grains contain a skeleton of silica, further in the presence of ferrous carbonate and phosphoric acid. s most probable too that the silica skeleton in the case of the nant limestone is due to the infilling of a cavity produced by ition of the calcium carbonate of the grains, which solvent action prevented from extending inwards by the insoluble nature of the on. On the whole it seems that the rock owes its distinctive acteristics to vegetable agency,—the peculiar form of the carbon rell as the other chemical constituents lending evidence in sup- of this view. This evidence would be much strengthened if the lstone residues described above should turn out to be a result of existence of plant life as suggested.

---

[1] Wethered, Geol. Mag. 1889, p. 196.

[2] Sorby, Q.J.G.S. vol. xxxv. (1879) Proc. p. 84.

-ON THE FLEXIBILITY OF ROCKS; WITH SPECIAL REFERENCE TO THE FLEXIBLE LIMESTONE OF DURHAM.

By George W. Card, A.R.S.M.;
sistant Demonstrator of Geology at the Royal College of Science, London.

E existence of rocks possessing, when the laminæ are not too thick, the property of flexibility has long been known. Upon ble sandstone ("Itacolumite") a great deal has been written at rent times, and of late years important work has been done h renders it necessary to greatly modify the opinions formerly with regard to this rock. Notwithstanding the interest which tached to the subject, it is one very much neglected by our text- s, the British, either ignoring it altogether, or treating it with utmost brevity, the German, while sometimes referring to it at iderable length, do not do more than enunciate the old views. Prof. Judd—who has kindly aided me with advice, and by afford- facilities for preparing this paper—I owe the suggestion that it ld therefore be useful to give a résumé of the present state of knowledge upon the flexibility of rocks in general. This paper accordingly be divided as follows:—

1. An account of the Durham Limestone.
2. Some remarks upon Flexible Sandstone.
3. A comparison of the two rocks.

The Flexible Limestone of Durham.—My attention was first cted to the existence of this rock by Mr. H. B. Woodward's ology of England and Wales."[3] Being well acquainted with Sunderland district, I determined to take the first opportunity of ing for the rock, and, such an opportunity having occurred ng the past summer, I now give the results of my work. So as I am aware, there are only three references to this variety.

---

[1] udd, Memoirs of Geol. Survey, Geology of Rutland, pp. 117–138; Hudleston, . Geol. Assoc. vol. xi. p. 104.

[2] ole and Jennings, Q.J.G.S. vol. xlv. (1889) p. 426.

[3] p. 219.

In his great memoir on the Magnesian Limestone, Prof. Sedgwick has the following passage:[1]—"The very thin laminæ of the latter (*i.e.* the earthy, finely-bedded limestone) variety, which occur in abundance near Marsden Rocks, are often slightly flexible, and very fine specimens of flexible magnesian limestone with thicker lamina occur in a bed near the middle of the cliff." The second referenc is that mentioned above, in "The Geology of England and Wales," and is to the same effect; while the third occurs in Bauerman' Mineralogy[2] under the heading "Dolomite," where it is stated tha the stone is flexible when freshly quarried, implying that th property is transient.[3]

It would thus seem as if the Marsden locality were the onl one from which flexible limestone has been described, but I wa fortunate enough to procure beautiful specimens on the coast a littl south of Sunderland, and therefore several miles from Marsde which lies about two miles south of the mouth of the Tyne. Fo some distance south of the Hendon dock the cliffs consist of Glacia Drift; passing this, and following the cliffs, now composed Magnesian Limestone, shortly before coming to the first point position is reached where considerable falls of stone occasionall occur. It was from a recent fall that the specimens to be describe were procured; the spot being about 1000 yards south of the Blu House Inn. From a similar fall in Marsden Bay, on the south sid near the Rocks, I also obtained specimens, but these were inferi to those from Sunderland, and will not be again referred to.

The cliffs here are mainly composed of a laminated magnesia limestone; that from above being earthy, friable, and comparativel unaltered, while in the lower portion of the cliff the stone, whi still tending to split along the bedding-planes, which are ver clearly marked, has been compacted by the re-crystallization of th whole. It is from the upper part that the flexible variety come Owing to the strike corresponding approximately with the trend the coast, the outcrop in the cliff is horizontal. Bedding is ve perfect, and many perfectly level slabs, of several square feet i area, have been brought down by the fall. It was from these sla that my specimens were procured; and I see no reason why, wi care, very large specimens showing flexibility might not be obtaine The colour of the stone is light yellow, the surfaces of the lamin are coated with a yellow powder which soils the fingers, laminatio is sometimes very perfect (·75 mm.), the whole being uniforml very fine in grain, and requiring careful handling because of i softness and friability. In general appearance it is, indeed, n unlike a fine-grained sandstone, and appears to have resulte chemically from deposition in successive layers.[4]

An interesting feature is the occurrence of many minute nests

---

[1] Trans. Geol. Soc. ser. ii. vol. iii. 1835, p. 87.

[2] Text-book of Descriptive Mineralogy, H. Bauerman, p. 353.

[3] However it may be at Marsden, this is certainly not the case at Sunderlan After having been kept in a dry place for several months, the specimens from th latter locality have undergone no loss of flexibility whatever.

[4] Sedgwick, *op. cit.* p. 86.

; mostly of about three or four millimetres diameter. These of a brown colour when very small, but when larger this ance is seen to be due to a coating of ferruginous matter lines the cavity in which the crystals occur. In one case a t geode of about 1 c.m. in diameter and lined first with ıginous coating and then with calcite crystals occurred. The ın of such a nest would be indicated externally only by a elevation on the surfaces of the lamina. This was especially se with the geode mentioned above; its position was clearly ted by a slight bulging of either side of the lamina in which ırred, the protuberance being flattened and marked with con› rings. It would seem as if such a geode might mark cipient stage in the formation of some of the concretionary ıres of which this series affords so many beautiful examples. cimen in my own collection may well have originated in this it is flattened on one side, irregularly dome-shaped on the with a cavity open on the flat side, and extending into terior of the dome. There are no cracks or any other comation across the planes of bedding, and the nests occur quite d—not in strings. It is therefore evident that they have ıted in the bed itself.[1] These structures will again be referred ɪn the case of the flexibility is dealt with.

ınalysis made under the superintendence of my friend Mr. W. ı.R.C.S., gave the following results:—

CO_2	46·476
CaO	30·744
MgO	21·169
FeO	·518
SiO_2	1·028
Total	99·935

ɪithstanding the friability of the stone, sections can readily pared transverse to the bedding planes. Mr. F. Chapman, repared mine, tells me he had no difficulty after soaking the ɪens in Canada-basalm. A low magnifying power reveals a number of irregularly-shaped empty spaces, in the main ed linearly in directions parallel to the bedding, but also ing promiscuously through the section.[2] With a ¼-inch ve the section is resolved into an aggregate of grains of -polarizing dolomite, the larger grains averaging about n. in diameter, with a very few minute grains of quartz, ıre and there of blue- and of brown-coloured minerals. With h, and still better with an ⅛-inch, the grains are seen to be ar in outline; the larger grains (sometimes attaining a er of ·02 mm.) frequently appear to be intergrown in such a at a convexity of one fits into a convexity of another, or a prointo a depression. Very rarely a minute piece of mica occurs. ing described the general appearance of the stone, the nature flexibility remains to be dealt with. In every case I find that the flexibility diminishes with the thickness of the lamina; pieces of 5 mm. or more in thickness exhibit the peculiarity in only a slight degree, while the laminæ of 1 mm. or less are very flexible indeed. Here, however, I may mention that the behaviour of specimens obtained from the same slab varied very much. A specimen of average flexibility and of 1 mm. or less in thickness feels almost leathery, bending over in all directions when held by one side or supported in the middle. A strip—trimmed down with a knife—5·3 cm. long, 2·5 cm. wide, and 1·5 mm. thick, supported at one end so that 5·3 cm. projected, gave the following results. By its own weight (4·4 grains) the strip bent until the free end was 1·6 cm. lower than the point of support. Now suspending it vertically it straightened itself in a few seconds and, on being turned over and once more supported at the same end, bent as before, but to not quite the same amount. By pressing the free end with the finger it was brought 3·1 cm. below the horizontal, when the strip broke off close to the point of support. Experimenting with another piece; after a little pressure had been applied to the free end, it straightened when suspended, but, when once more supported at one end in the same position, it assumed by its own weight a position approximating to that which it had been before bent by pressure.

---

[1] Sedgwick, *op. cit.*
[2] See Woodcut, Fig. A., p. 123, *infra.*

With regard to the cause of flexibility I can only offer the following suggestions. In the first place, room for internal movement is provided for by the abundance of empty spaces, and in the second, the structure revealed by high magnifying powers suggests the possibility that many of the grains are interlocked in such a way as to permit of a certain amount of movement upon one another.[1] Such an explanation would not be incompatible with the coherency of the rock; as a matter of fact the coherency is very slight, the material crumbling to pieces with great readiness: moreover, many of the grains are to be bound together in such a way that their margins cannot be made out. Owing to the small size of the grains, it is impossible to demonstrate whether they have such power of movement or not.

The empty spaces have, no doubt, resulted from the removal of carbonate of lime by percolating water. The bedding-planes have afforded the easiest passage, and it is along these planes that the cavities for the most part occur. It would appear as if much of the material so dissolved had been redeposited as calcite in the geodes.

2. *The Cause of Flexibility in "Itacolumite."*—Before considering this question, it is very necessary to arrive at some sort of an understanding as to what the rock which has been known as "Itacolumite," "Flexible-Sandstone," "Flexible-Quartz," and a variety of other names,[2] really is. Towards the close of the last century a peculiar siliceous rock was noticed in Brazil. Attention was directed to it principally because it often constituted the matrix in which diamonds occurred, but also because thin pieces of it were sometimes found to be flexible. Owing to its occurrence in the mountains of Itacolumi,

---

[1] See Woodcut, Fig. B., p. 123, *infra*.

[2] Third Report on the Geognostic Survey of South Carolina, 1848, p. 85, et. seq.

early writers referred to it as "Itacolumite"; a list of such references will be found in Zirkel's "Lehrbuch der Petrographie" (Bd. ii. p. 484). Subsequently similar rocks, also occasionally exhibiting flexibility, were discovered in other parts of the world, more especially in the Southern States of North America, and, at a later date, in India.

The term "Itacolumite" has been applied to the rock itself by most writers; Tuomey, who restricts it to the flexible variety, is an exception. The accounts given of the rock are fairly consistent, all agreeing in describing it as a stratified and granular variety of quartzite; frequently, especially in the case of the Brazilian and Carolina specimens, a good deal of mica occurs upon the bedding-planes.

Coming now to the terms applied to the flexible portion, "Sandstone" may be objected to on the ground that flexibility is at present unknown in unaltered siliceous sedimentary rocks, but Prof. Derby has pointed out [1] that there is no reason why it should not occur in sandstone.

Almost without exception the flexibility sometimes exhibited by "Itacolumite" has been ascribed to the quartz grains being enveloped by a flexible mineral variously referred to as mica, sericite, talc, or chlorite. As exceptions I may mention Klaproth and Prof. Haughton, both quoted [2] by Mr. Oldham, and von Hausmann, referred to by Zirkel.[3] Leibner, in the report on South Carolina before quoted, devotes a good deal of attention to the cause of flexibility, and considers that four conditions must be fulfilled, viz.:

1. "Fineness of grain."
2. "Sufficient admixture of mica or talc."
3. "Delicately laminated structure."
4. "Certain degree of compactness in the constituents of each lamina."

In this way he explains the very local occurrence of portions, since all the conditions must be fulfilled simultaneously. It would seem as if the flexible-mineral theory was at first nothing but a suggestion, but Leibner definitely gives his assent to it. Leaving the older views—which are still given in most text-books—two important papers have been lately published by Mr. Oldham,[4] and by Prof. O. Mügge respectively,[5] which propound quite different views as to the cause of flexibility. To these may be added a third by Prof. Derby [6] on the mode of occurrence of the Brazilian specimens. Prof. Derby's paper deals with the very local occurrence of flexible portions in the Itacolumite Series; the same mass of rock may contain "massive and schistose, compact and friable, non-flexible and flexible portions, within a distance of a few centimetres, and in exactly the same relative position in the bed." The author's conclusion is that flexibility is a *phase of weathering*. Tuomey came to the same conclusion with regard to the South Carolina stone, but Leibner differed from him.

---

[1] Am. Journ. Sci. xxviii. 1884, p. 205.

[2] Rec. Geol. Surv. India, vol. xxii. pt. 1, 1889, p. 53.

[3] Lehrbuch der Petrographie, 1886, Bd. 11, p. 482.

[4] On Flexible Sandstone or Itacolumite, R. D. Oldham, A.R.S.M., Records Geol. Surv. India, vol. xxii. pr. 1, 1889.

[5] Ueber "Gelenksandstein" aus der Umgegend von Delhi O. Mügge, Neuen Jahrbuch, Bd. i. 1887.

[6] On the Flexibility of Itacolumite, Orville A. Derby, Am. Journ. Sci. vol. xxviii. 1884.

Mügge describes the Delhi stone. There is a very little muscovite, but so small a quantity that it cannot possibly give rise to the flexibility. A small amount of clayey matter is present, not surrounding the quartz grains, but in patches which are not sufficient to fill the interspaces; the quartz is therefore much clearer than in ordinary sandstones, and the grains are in direct contact with one another; moreover, the grains have a very irregular outline (comparable to Babel-quartz), being very different in appearance from those of common sandstone. When examined in thin sections by means of polarized light, the quartz grains are seen to be hooked together. This interlocking accounts for the grains holding together, and at the same time allows of a certain amount of movement taking place, space for movement being afforded by the decomposition of the clayey patches. In this way the author thinks the flexibility can be explained. Dealing briefly with the Brazilian stone, he shows that the quartzes present an appearance almost identical with the Indian; there is very little clayey material, so that a section is almost as clear as water; while muscovite occurs only in small quantity, and in flakes much too short to envelop the quartz-grains. It is suggested that the structure of these rocks originated by a partial removal of the cementing material; the quartz-grains then resumed their growth, but the supply of material failed before the interspaces left on the removal of the clayey matter were completely filled.

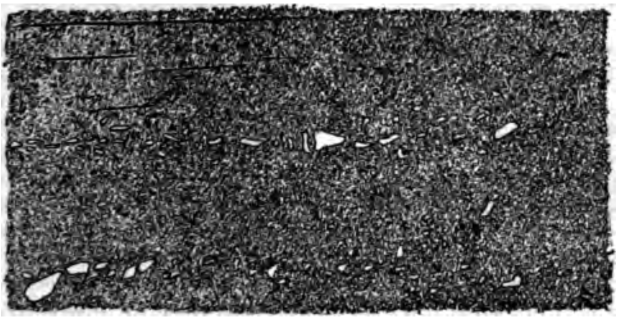
Mr. Oldham, also dealing with the Delhi specimens, arrived independently at the same results. In India, as in Brazil and in South Carolina, flexibility is correlated with decomposition. Examined under the microscope by reflected light a number of quartz-aggregates, separated by vacant spaces which appear to be ramifying fissures, are seen. These aggregates can be moved by a needle without displacement, the movement being the result of the grains being hinged together, a projection from one fitting into a depression in another. He also notices the occasional presence of felspathic paste, which, by its relative abundance and mode of distribution, determines the degree of flexibility that will be possible on its decomposition and removal. Having regard to the subject of this paper, one of the specimens described by Mr. Oldham is of special interest. It is a variety from Chárli, south of the Pemganga River (Berar). "An ordinary soft sandstone of rounded grains of quartz, with a little felspar, held together by a cement of carbonate of lime, *which forms 35·9 per cent. of the whole mass.*[1] Here there is no comparatively soluble material whose removal leaves the rest of the rock as a mass of irregular aggregates interlocking with each other, for on removal of the cement, by solution, the rock falls into sand.'

---

[1] The italics are mine.

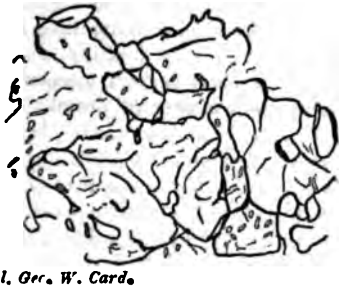
But if the fractured surface of the rock is examined, an abundance of sheeny patches point to a crystallization of the cementing matrix, and these crystals offer a number of planes in various directions along which solution proceeds with greater rapidity than elsewhere; and as a result the rock becomes divided into irregular interlocking aggregates of sand and calcite."[1] The mode of interlocking in both varieties is illustrated by drawings.

Section of Flexible Limestone from the coast, a little south of Sunderland (see *ante*, pp. 118-120).



Del. Geo. W. Card.

FIG. A.—Flexible Limestone cut transverse to bedding, and showing empty spaces. × 10. (p. 119.)



Del. Geo. W. Card.

FIG. B.—Flexible Limestone highly magnified. × about 400. (p. 120.)

An examination of a section of the North Carolina material in the collection of this institution gives similar results: the quartzes are very clear, have very irregular outlines, and are generally in direct contact; there are a number of cavities, and apparently an articulation of the grains, while mica is present in very small quantity only.

3. It will now be useful to briefly compare these "sandstones" with the Durham Limestones. In thin laminæ the flexibility is very similar in degree; Leibner found that a strip of Carolina Sandstone, very similar in dimensions to the strip of limestone used by myself,

---

[1] p. 54.

but a little thicker ($\frac{1}{10}$-inch), bent under pressure through a vertical distance equal to somewhat less than half the length of the strip; the limestone gave slightly higher results, but was somewhat thinner (1·5 mm.). In slabs of greater thickness, however, the superior flexibility of the Itacolumite is very marked; thus Mr. Oldham found a piece 17 inches long by ·75 inch thick bent through 7 inches of its own weight, while in slabs of limestone of 5 mm. thickness flexibility becomes very slight. They agree also in a decrease of flexibility accompanying increase of thickness. In both cases the occurrence of flexible portions is very local; this has already been referred to, but it may be mentioned further that fine-grained, bedded, non-flexible limestones occur in the neighbourhood, and it would be interesting to know whether these non-flexible beds possess the internal structure described above. It is, however, in internal structure that the resemblance is most marked, both exhibiting a number of vacant spaces accompanied by an interlocking of the constituent crystalline grains. Flexibility would thus seem to arise from similar causes; we have room for movement afforded by empty spaces, the result of solution of carbonates in the one, and of the decomposition and removal of patches of felspar in the other; while the direct cause of bending is the interlocking of the grains.

It is well known that a distinct sound is heard when flexible sandstone is bent; the limestone does not give rise to any sound that is audible, but, from the inferior hardness of calcite, as compared with quartz, this is no more than might be expected.

Lastly, there is the occurrence of the calcareous rock at Chárli. This may, indeed, be regarded as a connecting link between flexible Itacolumite on the one hand and flexible limestone on the other. It is not only that it contains a certain proportion of carbonate of lime; that might be quite a matter of detail; but from the passage quoted above it would seem that the calcite plays an important part, forming interlocking aggregates, and affording the space necessary for movement by its solution. Moreover it is described as a common sandstone, the grains of quartz being somewhat rounded; this would seem to emphasize the presence of the calcite, as it is not clear what part such quartz can take in effecting movement.

In conclusion, now that a number of rocks are known to exhibit the property of bending without fracture, in each case the phenomenon being no more than a natural concomitant of certain phases of alteration, the undesirability of giving distinctive names to the different varieties will be at once apparent. Indeed, there seems no reason why many other varieties should not also occur, although, from the nature of the conditions to be fulfilled, we cannot expect to find flexible beds in considerable quantity.

I have already acknowledged my indebtedness to Prof. Judd, and it only remains to state that this work has been carried out in the Geological Laboratory of the Royal College of Science.

REVIEWS.

I.—Classification of the Moas (Dinornithidæ) of New Zealand.

We have received from Prof. F. W. Hutton, F.G.S., an abstract of a paper read by him at the Canterbury Philosophical Institute on Oct. 1st, 1891, in which the classification of the extinct flightless birds of New Zealand is discussed. Mr. Lydekker having recently treated the subject at length in the British Museum Catalogue of Fossil Birds, from an examination of the material now in the Museums of London, Capt. Hutton's work is especially opportune; and it is to be hoped that before the printing of this memoir, based upon the unrivalled specimens in the New Zealand Museums, the author will have the opportunity of incorporating the results of his British co-labourer. Both Mr. Lydekker and Capt. Hutton recognize several new specific types, and it is especially desirable that the forms just determined by Mr. Lydekker should not be re-named in the forthcoming work.

Captain Hutton regards the known Dinornithidæ as divisible into seven genera and twenty-six species. "The genera are founded chiefly on the skulls, but also have characters derived from the sternum, pelvis, and the robustness of the leg-bones. The species are distinguished almost entirely by size, but sometimes characters derived from the skull can be given. In many cases the species run one into the other, and the lines between them are drawn so as to give about an equal range in variation to each species."

The generic diagnoses are as follows:—

Genus Dinornis. Skull depressed, the lambdoidal ridge flattened and the parietals hardly rising above it; the breadth at the squamosals greater than the length from the supra-occipital to the nasals. Beak rather longer than the head, depressed and obtuse at the tip; the lower jaw much curved. A scapulo-coracoid without any glenoid cavity. Including sub-genus *Dinornis* ("Top of head flattened") with species *altus*, *maximus*, *giganteus*, *robustus*, *ingens*, and four new species; also sub-genus *Tylopteryx* ("Top of head elevated") with species *gracilis*, *struthioides*, and one new form.

Genus Palapteryx. Skull depressed; the breadth of the squamosals less than the length from the supra-occipital to the nasals. Beak about as long as the head, more compressed than in *Dinornis*; the lower jaw nearly straight. A scapulo-coracoid with a glenoid cavity and probably a wing. Including *P. dromioides* and one new species.

Genus Anomalopteryx. Skull very convex, the maxillo-jugals curved. Beak short, slightly compressed and rounded at the top; the lower jaw strong and nearly straight. A small scapulo-coracoid. Including *A. didiformis* (=*A. parvus*), and one new species.

Genus Cela. Skull convex. Beak short, slightly compressed and rounded at the tip; the lower jaw nearly straight and rather slighter than in *Anomalopteryx*. No scapulo-coracoid. Including *C. geranoides* and *C. curtus* (=*Dinornis Oweni*, Haast).

Genus Mesopteryx. Skull convex, angled behind. Beak shorter than the head, moderately curved, much compressed and pointed at the tip; the lower jaw slender. No scapulo-coracoid. Including *M. didinus* (=*Dinornis Huttoni*).

Genus Syornis. Skull convex, rounded behind. Beak shorter than the head, moderately curved, much compressed and pointed at the tip; lower jaw strong. No scapulo-coracoid. Including *S. rheides*, *crassus*, and *casuarinus*.

Genus Euryapteryx. Skull moderately convex. Beak very short and stout, slightly compressed and rounded at the tip; the lower jaw moderately curved. No scapulo-coracoid. Including *E. elephantopus* and *E. gravis*, with two new species.

In a popular summary of his results, contributed to a local newspaper, Captain Hutton makes some interesting comments on the remarkable diversity thus recognized among the extinct Struthious birds of New Zealand. He considers that a plausible explanation of the facts may be deduced from the known distribution of the existing Cassowary. One species inhabits Australia at the present day, and eight others occur on the islands from New Britain to Ceram. The eight species inhabit five different islands, "and if this region of the earth were to be elevated, and the islands joined together, these eight species would mingle. If the region were to sink once more all of them would be driven to the highest land, and might be crowded into one small island. Now, we know from geology, that New Zealand has gone through a series of changes in level, similar to those just mentioned. In the Miocene period it consisted of a cluster of several islands, which were elevated and united in the older Pliocene, and ultimately divided into the two islands we have now in the newer Pliocene. If the ancestors of the Moas inhabited New Zealand during the Eocene period, they must have been separated on these islands during the whole of the Miocene, and mingled together again in the Pliocene. In this way—*i.e.* by isolation—probably the genera originated, but the species appear to be due to variations without isolation. As is the case with most common animals, the Moas varied greatly, and, there being no carnivorous mammals to hold them in check, while vegetable food was abundant, natural selection did not come into play, and the intermediate forms were not strictly eliminated. Under such favourable circumstances the conditions of life were easy, and the birds got larger and fatter, more sluggish and more stupid. The oldest known Moa is one of the smallest, and it is the smaller species which are found in both islands; from which we may infer that they were the only ones in existence when the two islands were united, and that the Moas since then increased in size. But the very large Moas were always comparatively rare. The commonest kinds in the North Island were only from two and a half to four feet high, while those of the South Island were mostly from four to six feet in height. The giant forms, going up twelve and thirteen feet, were seldom seen."

Such speculations are an incentive to further research, and both zoologists and geologists will anxiously await the appearance of a memoir that will evidently touch problems of very wide import.

II.—Mémoire sur la Faune du Grès Armoricain, par Charles Barrois. Annales de la Société Géologique du Nord, Tome xix. pp. 134–237, Pls. I.–V. April, 1891.

THE rocks in Brittany known as the 'grès armoricain,' have a special interest from the fact that they are pretty well the lowest in France from which specifically determinable fossils have been obtained. M. Lebesconte has partly described and figured from them, fragments of Trilobites belonging to the genera *Ogygia* and *Homalonotus* and some years since the late Dr. T. Davidson[1] figured and described in the pages of the GEOLOGICAL MAGAZINE several species of *Lingula* from the same horizon. A few other fossils, Mollusca principally, were also known in these beds; but owing to the fact that these forms were in poor preservation, existing only as moulds, no systematic attempt had been made to determine them. In spite of this obstacle Dr. Barrois has succeeded in working out this group, and has described and figured in this memoir no fewer that 29 species of Lamellibranchs, 13 of which are new forms. The principal genera represented are *Actinodonta*, Phillips; *Lyrodesma*, Conrad; *Redonia*, Rouault; *Ctenodonta*, Salter; *Nuculites*, Conrad; *Nuculana*, Link; *Cyrtodonta*, Billings; *Modiolopsis*, Hall, and *Hippomya*, Salter. The Gasteropoda are included in *Palæacmæa*, Hall, and *Bucania*, Hall, and there is a single species of *Conularia*. There are also some Crustacea referred to *Myocaris*, Salter; *Ceratiocaris*, M'Coy, and *Trigonocarys*, gen. nov. Specimens of the peculiar fossil *Discophyllum* (*Actinophyllum*) *plicatum*, Phillips, sp., also occur in the grès armoricain, and they are ranked by the author as calcareous sponges, similar to those of the family Pharetrones, Zittel; but after a careful examination of Phillips' types, we fail to recognize any characters which can ally them to sponges.

---

[1] Geol. Mag. Vol. VII. (1880), p. 342, Pl. X.

Including forms previously known, Dr. Barrois now enumerates a list of 45 species of invertebrate fossils from the 'grès armoricain' in the departments of Ille-et-Vilaine and Loire Inférieure.

Taking into account the occurrence of the genera *Ogygia* and *Homalonotus*, and of the Lamellibranchiata now described, the author is fully justified in concluding that the fauna cannot be Primordial, but he considers that it is intermediate between this latter and the Llandeilo fauna. There is a very significant similarity between many of the Lamellibranch genera of the 'grès armoricain' and those occurring in the Trenton and Chazy groups of Canada and the United States, thus indicating a nearer relation to these rocks than to the underlying Calciferous formation in these countries. Again, when compared with British strata, the molluscan fauna of the 'grès armoricain,' approaches nearer to that of the base of the Arenig than to that of the older Tremadoc. If this supposition is correct, the fauna of the 'grès armoricain' cannot correspond with the earliest period of the second Silurian fauna, and consequently neither a Tremadoc nor a Primordial fauna has yet been discovered in Brittany. Notwithstanding the identity of the Bilobites and Scolites in the 'grès armoricain' with those of the Lingula Flags, the author states that these rocks cannot be compared together in point of age.

Touching the classification of the schists, conglomerates, phyllades, etc., which in Brittany occur beneath the 'grès armoricain,' considerable differences of opinion exist among French geologists, but Dr. Barrois adopts that of Dufrenoy, and considers the Étage of Gourin to correspond with the horizon of the Primordial fauna, and the phyllades of St. Lô with the Longmyndian of Callaway.

G. J. H.

III.—Om mynningen hos *Lituites*, Breyn. Af Gerhard Holm. Geol. Fören. Forhandl. No. 140, Bd. 13, Häft 7, 1891.

On the Aperture in the genus *Lituites*, Breyn. By Gerhard Holm. Transactions of the Geological Society in Stockholm, Vol. 13, pp. 736–780, Pls. 10–12.

THE terminal aperture of the shell in the Lower Silurian Cephalopod genus *Lituites*, Breyn, is so seldom preserved intact, that different views have been maintained respecting its true form. Quenstedt stated that it was furnished on the ventral side with two projecting straight lobes. Noetling showed later that there were four of these lobes, one pair on the ventral and the other on the dorsal side; but in the lately published Brit. Mus. Cat. of the Cephalopoda, A. H. Foord adopts the statements and figures of Lossen that not more than two incurved lobes are present, and considers Noetling's observations erroneous. Dr. Holm has obtained some very perfect individuals both of *Lituites lituus*, Montf., and *L. tenuicaulis*, Rem., which show clearly that in the aperture of these species, there is, in addition to the two pairs of lobes described by Noetling, another small unpaired lobe on the dorsal side, so that, when complete, there are five lobes. This number seems to prevail in the majority of the species, but the author describes a new form, *L. discors*, in which only three lobes are present, and another, *L. præcurrens*, which may possibly only have possessed two lobes, and on account of its strongly marked conical form would come into the so-called genus *Ancistroceras*.

A new species of *Cyclolituites*, Remelé, is also described, which definitely shows that the forms placed in this genus are not merely the loose spirals of species of *Lituites*, but distinct members of the Lituitidæ family, from which probably the typical *Lituites* have been developed.

G. J. H.

IV.—The Fossil Insects of North America, with Notes on some European Species. By Samuel H. Scudder. Vol. I. The Pretertiary Insects, with Thirty-five Plates. 4to. pp. 456. Vol. II. The Tertiary Insects of North America. 4to. pp. 734, with Twenty-eight Plates.[1] New York: Macmillan & Co. (1891).

THE Essays contained in the first volume of the present work have (the author tells us) no logical connection. They were written and printed at different times during the past twenty-five years, and are here issued exactly as first printed. But they cover nearly the whole of a single limited field in palæontology, of which the author may be said to be almost the sole exponent in America. Mr. Scudder's name is now as familiar to European Palæontologists as it is to those of America, and, so long ago as 1868, he communicated to the Geological Magazine, at the request of Sir Charles Lyell, a most valuable digest "On the Fossil Insects of North America," so far as then known (Geol. Mag. Vol. V. pp. 172–177, and pp. 216–222).

---

[1] For a Review of vol. ii., see Geol. Mag. 1891, Decade III. Vol. VIII. pp. 280–282.

1. The volume opens with an essay on "the first discovered traces of Fossil Neuropterous Insects in North America," and was read before the Boston Society of Natural History, in January, 1865, (published in 1866 with one plate).

2. The second is on "the Carboniferous Myriapods preserved in the Sigillarian stumps of Nova Scotia."

3. Next follows a short essay on "the early types of Insects; or the origin and sequence of Insect-life in Palæozoic Times."

4. The fourth paper on "Palæozoic Cockroaches," *with a revision of the species of both worlds,* and an essay on their classification (illustrated by five quarto plates), is one of Mr. Scudder's most important contributions.

At first glance at the plates it would appear as if the materials at the author's disposal were better preserved and more abundant than usually falls to the lot of any single student of fossil insects; but the figures occupying the first three plates out of the five illustrating this paper, are copies from the plates of Germar, Goldenberg, Giebel, Heer, etc., of all the then known European forms (1879), the last two only being drawn from original American specimens.[1]

It is doubtless a very great convenience to have the whole of the forty-nine European forms redrawn and brought together thus for comparison with the eighteen American species, but the complete *revision* of all the European species, from the figures and descriptions alone, must be a somewhat hazardous task without seeing the original specimens as well. However, we may be very thankful to Mr. Scudder for his scheme of classification, nor are we likely to better it, for some time to come.

The specimens figured are all detached wings, and the proposed arrangement is based solely upon their neuration.

5. The next Memoir is on "The Devonian Insects of New Brunswick" (illustrated by Plate 7), first described and figured (by Scudder) in a paper by Sir William Dawson in the GEOL. MAG. 1867 (Vol. IV. pp. 385–388, Pl. XVII. Figs. 1–5).

6. The sixth Memoir is on the "Archipolypoda, a subordinal type of spined Myriapods from the Carboniferous formation" (with four plates).[2] This Essay is particularly interesting to English palæontologists on account of the discovery of similar forms of spined Myriapods in the English Coal-measures.[3]

7. The next paper is on "The Carboniferous Hexapod Insects of Great Britain," and describes and figures (*a*) *Brodia priscotincta,* Scudder, from a Clay Ironstone nodule of the Coal-measures, Tipton, Staffordshire; (originally described and figured (as a woodcut) in GEOL. MAG. Dec. II. Vol. VIII. p. 293, 1881). (*b*) *Archæoptilus ingens,* Scudder, a fragment of the base of the wing of a large Neuropterous insect, from the Coal-measures near Chesterfield, Derbyshire, and

---

[1] Mem. Soc. Nat. Hist. Boston, 4to. vol. iii. pp. 23–134, pls. 2–6.

[2] Originally published Mem. Boston Soc. Nat. Hist. vol. iii. No. v. pp. 143–182, pls. x–xiii. 1882.

[3] See H. Woodward, "On some Spined Myriapods from the Carboniferous Series of England," GEOL. MAG. Dec. III. Vol. IV. Pl. I. pp. 1–10, 1887.

is like the preceding example in the collection of the Rev. P. B. Brodie (Geol. Mag. 1881, p. 295).

8. This paper is on "Two New and Diverse Types of Carboniferous Myriapods;"[1] namely *Trichiulus villosus, T. nodulosus*, and *T. ammonitiformis* (no longer a myriapod). *Palæocampa anthrax* from the ironstone nodules of Mazon Creek, Morris county, Illinois (illustrated by two plates).

9. The ninth paper is on "the species of *Mylacris*, a Carboniferous genus of Cockroaches," of which Mr. Scudder describes six species founded on six detached wings, which are also figured. They are from Mazon Creek, Pittston, and Cannelton, Pennsylvania.

10. This essay is devoted to "The Earliest Winged Insects of America: a re-examination of the Devonian Insects of New Brunswick, in the light of criticisms and of new studies of other Palæozoic types."

Surely these remains are too fragmentary and obscure to devote more time to their re-examination or lengthy discussion. It would be more profitable to look for better materials to study.

11. On "Palæodictyoptera: or the affinities and classification of Palæozoic Hexapoda."

In this paper the author describes and figures (in four quarto plates) a number of new Carboniferous winged insects principally from Mazon Creek, Illinois. One form, *Archægogryllus priscus*, is considered to belong to the Orthopteroid-Palæodictyoptera; but the twenty-three other forms named and figured are referred to the Neuropteroid section. The neuration of many of these forms, preserved in ironstone nodules, is obscure and very difficult indeed to trace with accuracy, and therefore their determination must be to a considerable extent tentative.

12. "Winged Insects from a Palæontological point of view, or the Geological History of Insects." In this paper the author contends that throughout Palæozoic times insects continued as a generalized form of Heterometabola which he calls Palæodictyoptera, and which had the front wings, as well as the hind wings, membranous. On the advent of Mesozoic times a great differentiation took place, and before its middle, all of the orders, both of Heterometabola and Metabola, were fully developed in all their essential features as they exist to-day, the more highly-organized Metabola gradually becoming the prevailing type (p. 322).

13. The thirteenth paper is on "the oldest-known Insect-larva (*Mormolucoides articulatus*) from the Connecticut River Rocks" (Triassic).[2] (See pl. 19, and woodcut, p. 323.)

14. This is "A Review of Mesozoic Cockroaches," dealing with the Secondary forms of Blattariæ after the manner in which the Palæozoic forms were dealt with in Essay No. 4, only in this case *all the species* figured and described are British or European, but almost all are from the Lias or the Purbecks of England. Many of

---

[1] Originally printed in Memoirs of the Boston Society of Natural History, vol. iii. No. ix. 1884.

[2] Published in the Geol. Mag. Vol. V. 1868, p. 218, without a figure.

them are based on fragments from the Purbeck, which Westwood named but did not describe; or figured, but did not name; or, which Brodie found but did not name or describe. These wings are for the most part fragmentary and must have required good courage to found species upon them. Surely there is something wrong about *Pterinoblattina penna!* (pl. 22, fig. 14). Is it an insect-wing at all?

15. Is on some "New Types of Cockroaches from the Carboniferous Deposits of the United States." These forms, which fill two quarto plates, are considerably better-preserved remains than any of the others previously figured; fig. 5, pl. 23, *Archimylacris paucinervis*, and fig. 3, pl. 24, *Oryctoblattina occidua*, being very remarkable and aberrant forms. These cockroaches are from the Richmond, Ohio, coal-field, and from Mazon Creek, Illinois.

16. This paper is devoted to more "New Carboniferous Myriapoda from Illinois." The greater number of specimens are referred to the genus *Euphoberia* and to eight species. The other to *Acantherpestes*, *Archiulus*, *Xylobius*, *Ilyodes*, *Latzelia*, *Palænarthrus* and *Eilecticus*. These are mostly from Mazon Creek, Illinois, and are very beautifully drawn on six quarto plates illustrated by fifty-seven figures.

17. Is devoted to "Illustrations of the Carboniferous Arachnida of North America of the orders Anthracomarti and Pedipalpi."

The Anthracomarti is said to be the only extinct order of Arachnida, and was established by Karsch for some interesting Carboniferous forms allied to the Phrynidæ and Phalangidæ, although very distinct from either of them.

To this group belong forms like *Eophrynus Prestvici*, H. W. (1871), from the Coal-measures, Coalbrook-dale; *Architarbus subovalis*, H. W. (1872), Coal-measures, Lancashire; numerous allied forms from the Permo-Carboniferous of Bohemia. Another form, named by Woodward as *Brachypyge carbonis* (Geol. Mag. 1878, Pl. XI. p. 434), from the Coal-measures of Belgium, has since been removed (at the suggestion of Mr. Scudder) to the Anthracomarti, near to *Eophrynus* (see Geol. Mag. 1887, p. 49, footnote). Scudder's genus *Geraphrynus* (pl. 32, figs. 1, 9, 10) and his *Anthracomartus* (pl. 31, figs. 7–10) must be very near to *Eophrynus*. Of the order Pedipalpi, Scudder's *Geralinura carbonaria* is also represented in the Coal of Bohemia by several closely allied species.

18. The last paper is on "The Insects of the Triassic beds at Fairplay, Colorado." These include thirteen species of Palæoblattariæ and Blattariæ and three species of Hemiptera. The descriptions of these cockroaches are based on wings, but two or three species are founded on the pronotum alone.

The volume concludes with a Biographical note on American Literature, treating of the older fossil Insects; followed by an Index and thirty-four excellent plates.

Most of the papers are undated and need references, but they have, as a rule, been all published, in their present form, at various times, in the Memoirs of the Boston Society of Natural History.

Vol. II., which treats of the Tertiary Insects of North America, is a reprint from vol. xiii. of the Report of the United States Geological

Survey of the Territories (1890), which has already been noticed (see Geol. Mag. 1891, p. 280). It includes the (Oligocene) Tertiary Insects of Florissant, South Colorado; those of the White River, West Colorado; Eastern Utah; and Wyoming.

From Quesnel, British Columbia, Dr. G. M. Dawson has contributed numerous insects; and Dr. G. J. Hinde from Clay-beds, near Toronto, Canada, has added materials for 29 species.

Alas! but few of those who, like the author, have devoted a life-time to palæontology, ever have the good fortune to see, at the end of thirty years, their scattered brochures reprinted as a pair of handsome quarto volumes! To many of us, the process would certainly not be feasible, *commercially*. To most it would hardly be a scientific gain. Compared with man's best efforts after all, how much more enduring is the Epitaph which Nature has engraved upon the rocks to the Memory of the humble but long-lived Cockroach!

° ° ° ° ° ° °

Diving into our Editorial waste-paper basket to-day we drew forth the following lines, grimy with soot, and inscribed :—

"Manchester, Brit. Assoc. 1887.

"In times Carboniferous Scudder has shown,
That the Cockroach was gaily then holding his own ;
Do you think that in our case we too may last,
If we stick to the Cook and the Kitchen as fast?"

(The second verse has, alas! been torn off, and is lost to science.)

H. W.

V.—Geological Survey of Western Australia. Annual General Report for the Year 1890. By Harry Page Woodward, F.G.S., etc., Government Geologist. 8vo. pp. 53. (Perth, W.A., 1891.)

The last Report of the Government Geologist in Western Australia, was noticed in the Geological Magazine for October, 1890 (p. 468); and we then printed a Table of the Strata, which need not here be repeated, as no additions or alterations are necessary.

In the present Report Mr. Harry P. Woodward gives a list of the fossils which, up to the present time, have been found in Western Australia. Some of these have been described in the Geological Magazine, as previously noticed.

Among the Cambrian fossils, the record of *Olenellus Forresti*, associated with *Salterella Hardmani*, is of especial interest. Although this *Olenellus* was identified with a query by Mr. A. H. Foord, yet further knowledge of the genus, as lately published by Mr. C. D. Walcott, leaves no room to doubt that the query may be cancelled; and indeed this element of doubt has been omitted from the Report. With regard to the Carboniferous and Devonian rocks it is remarked that "there seems to be an unbroken series of beds, the Lower Carboniferous fauna gradually merging into the Devonian"—a matter of considerable interest, as this is undoubtedly the case in Europe and North America.

In future lists of the fossils it would be convenient if the names of authors were appended; and the opportunity might be taken to correct some misprints in the names.

The Report contains a general geographical and geological description of the Victoria, Murchison, Gascoyne, Ashburton, Fortescue, Roebourne, and De Grey districts, with particular accounts of the mineral resources.

Alluvial gold was found by the Ashburton river in 1890; it has been derived from mineral veins in clay-slates. These slates are highly inclined, and on their upturned edges rest limestones and other strata of Devonian and Carboniferous ages. The Ashburton gold-field yielded about 15,000 ounces of gold in six months. At present only the rich patches in the shallow ground have been worked; the deep ground is as yet untouched, although in the large plains of the Ashburton river rich deposits are sure to be found, and it is likely to prove a permanent goldfield.

Mr. Woodward remarks that "as the prospecting will be most expensive work, no one will undertake it, unless he be granted a protection area, until the course of the leads has been ascertained."

The Pilbarra Goldfield is also reported to be "one of the most promising mineral areas in this Colony." Particulars are likewise given of the progress of the Yilgarn and Kimberley Goldfields, of the Greenbushes Tinfield, and of the Collie River Coal-district.

The Collie Coal is stated in the Report to be "a Mesozoic coal, of first class quality," but from specimens subsequently submitted to Mr. Etheridge, he expresses his belief that it is "a good and true Palæozoic coal" (*West Australian*, Jan. 13, 1892). The question of age will not seriously affect the colonists, so long as the coal is good, and there is plenty of it. The extent has yet to be proved.

VI.—GUIDE THROUGH THE COLLECTION OF BUILDING-MATERIALS IN THE IMPERIAL-ROYAL NATURAL-HISTORY COURT-MUSEUM OF VIENNA. [Führer durch die Baumaterial-Sammlung, etc.] compiled by FELIX KARRER; with a Preface by the Editor, Dr. ARISTIDES BREZINA, Director of the Mineralogical Department. Small 8vo. 302 pages, with 40 Illustrations. Vienna, 1892.

IN the Introduction the rocks and minerals supplying materials for construction are enumerated and briefly described, and then referred to their respective geological ages and formations. A bibliography relating to building-materials is also given.

The contents of this useful work are arranged thus:—I. Austrian-Hungarian Monarchy: A. Cisleithania; 1. Lower Austria, especially Vienna, with illustrations of St. Stephen's, the Votive Church, Government Buildings, Townhall, Natural-history Court-Museum, Marie-Therese Monument, the University, Court-Town-theatre, and the Court-Operahouse. The enumeration, definition, and localities of the several kinds of natural and artificial stone, plaster, etc., are carefully given, as road-materials, paving-stones, brick-earths, mortar-sand, lime, cement-stones, building-stones, decorative-stones, roofing-slates, artificial stones, fire-bricks, terra-cotta, stucco, etc. A supplemental list of materials besides those used in Vienna; and one of the old collection of the Society of Austrian Engineers and Architects, are added. 2. Upper Austrian; 3. Salzburg; 4. The Tyrol; 5. The Vorarlberg; 6. Styria; 7. Carinthia; 8. Carniola; 9. Görz and Gradisca; 10. Trieste; 11. Istria; 12. Dalmatia; 13. Bohemia; 14. Moravia; 15. Silesia; 16. Galicia; 17. Bukowina. For these districts, the chief cities are noted with illustrations of several important buildings, and an enumeration of the local building-materials in relatively the same order as those described for Vienna.

B. In the Kingdom of Hungary, we have—(1) Budapest, its chief buildings and materials; also (2) the materials used in Siebürgen, and (3) Croatia.

II. The foreign localities and their building-materials here mentioned are:—Germany, Italy[1] (including ancient Rome), France, and Belgium, with illustrations of several of their chief buildings; also lists from England, Norway, Russia, Switzerland, Spain and Portugal, Greece, the United States of America, Asia, and North Africa.

The assistance given to the author by merchants, manufacturers, and scientific friends, with information and specimens, is duly acknowledged throughout the book.

This catalogue raisonné of Eastern-European and other building-materials is a very valuable addition to the bibliography of the subject; and the fine collection to which it is a guide is indeed, as Dr. Brezina remarks in the preface, a lasting monument to **Felix Karrer**, who has devoted much time and labour to the formation of this important part of the Vienna Museum. T. R. J.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 27, 1892.—Dr. W. T. Blanford, F.R.S., Vice-President, in the Chair.—The following communications were read:

1. "On the Hornblende-schists, Gneisses, and other Crystalline Rocks of Sark." By the Rev. Edwin Hill, M.A., F.G.S., and Prof. T. G. Bonney, D.Sc., F.R.S., V.P.G.S.

The authors refer to Mr. Hill's paper, published in 1887, for a general description of the Island. They were led to examine Sark again in the hope that its rocks might afford some clue to the genesis of the hornblende-schist of the Lizard. They describe the structure, macroscopic and microscopic, of the various foliated rocks. These are:—(*a*) The basement gneiss, a slightly foliated, somewhat granitoid rock, probably of igneous origin, but with some abnormal environment, and possibly intrusive into, instead of older than the rock which succeeds it. (*b*) The hornblende-schists, almost identical with those of the Lizard, but in one case yet more distinctly banded. (*c*) Banded gneisses sometimes rather fine-grained, variably banded: quartzofelspathic layers alternating with those rich in biotite or occasionally hornblende. Some of these gneisses resemble the "granulitic group" of the Lizard; others recall certain of the less coarse, well-banded gneisses of Scotland, *e.g.* south of Aberdeen. Sometimes they are much "gnarled" by subsequent earth-movements, by which, however, as a rule, the crystalline rocks of the Island do not appear to have been very seriously affected. (*d*) A very remarkable group of local occurrence which exhibits great variety. In some places large masses of a dark green hornblende-rock are broken up and traversed by a pale red vein-granite or aplite. The former rock is drawn out into irregular lenticles, elongated lumps, and finally streaks, and has been melted down locally into the aplite. This then becomes a well-banded biotite gneiss, which macroscopically and microscopically agrees with types which are common among the Archæan rocks. Sark therefore presents an example of the genesis of such a gneiss, and the authors are of opinion that probably all the above-named rocks are of igneous origin, but became solid ultimately under somewhat abnormal conditions, to which the peculiar structures (which distinguish them from ordinary igneous rocks) are due. They attribute the banding to the effect of fluxional movements, anterior to final consolidation, in a mass to some extent heterogeneous. This hypothesis they consider may be applied to all gneisses or schists which exhibit similar structures—that is, to a considerable number (but by no means all) of the Archæan rocks.

---

[1] See Geol. Mag. April, 1889, pp. 174–177, for a notice of Chevalier Jervis's work on the "Economic Geology of Italy," treating of Italian materials of construction, ancient and modern, with numerous illustrations of public buildings.

The second part of the paper consists of notes on some of the dykes and obviously intrusive igneous rocks of the Island. Among these are four (new) dykes of "mica-trap," one of which exhibits a very remarkable "pisolitic" structure. The variety of picrite described by Prof. Bonney in 1889 (from a boulder in Port du Moulin) has also been discovered *in situ*.

2. "On the Plutonic Rocks of Garabal Hill and Meall Breac." By J. R. Dakyns, Esq., M.A., and J. J. H. Teall, Esq., M.A., F.R.S., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

The plutonic rocks described occur in a complex forming a belt of high ground S.W. of Inverarnan. They vary considerably in composition, and though gradual passages are sometimes found between more or less acid rocks, at other times the junction is sharp. The more acid are always found to cut through the less acid when the two rocks are found in juxtaposition, and fragments occurring in a rock are less acid than the rock itself. Though thus shown to be of different ages, they must evidently refer to one geological period. The first rocks to be formed were peridotites; then followed diorite, tonalite, granite, and eurite in order of increasing acidity.

The specific gravities, colours, and textures of the rocks are considered, and a detailed account of the constituent minerals given.

The essential minerals are arranged in the following order, based on their general distribution in the different type of rock:—Olivine, pyroxene, hornblende, biotite, plagioclase, orthoclase and quartz, microcline. The following is the order in which the principal constituents commence to form in the rocks:—Iron-ores, olivine, pyroxene, hornblende, biotite, plagioclase, orthoclase, microcline, and quartz. The chemical composition of the rocks is discussed, data being furnished by a series of analyses made by Mr. J. H. Player, and a diagrammatic representation of the molecular relations of the different bases and silica is given. The relations between mineralogical composition, chemical composition, and geological age are then considered; and the following conclusions are reached:—

(1) That the various rocks have resulted from the differentiation of the originally homogeneous magma.

(2) That the chronological sequence from peridotite to eurite is connected with the order of formation of minerals in igneous magmas.

3. "North Italian Bryozoa.—Part II. Cyclostomata." By Arthur William Waters, Esq., F.G.S.

The Chilostomata from the same localities were dealt with in volume xlvii. of the "Quarterly Journal." In the present paper a number of Cyclostomata are described, amongst the most interesting being a new species termed by the author *Diastopora brendolensis*, which has tubules similar to those of *D. obelia.* These are the only species in which tubules are known, and two modes of growth of the fossil seem to show that those who united under *Diastopora* erect and incrusting forms were right.

The ovicell by the side of the zoarium of *Hornera serrata*, described in the paper, is in a position new for the Cyclostomata.

II.—Feb. 10, 1892.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "The Raised Beaches, and 'Head' or Rubble Drift of the South of England: their relation to the Valley Drifts and to the Glacial Period; and on a late Post-Glacial Submergence.—Part I." By Joseph Prestwich, D.C.L., F.R.S., F.G.S.

The author remarks that, besides the subaerial, fluviatile, and marine Drifts of the South of England, there is another Drift which is yet unplaced. This he considers to be connected with the 'Head' overlying the Raised Beaches. Of these he describes the distribution, characters, and relations along the South Coast. The 'Head' overlies the beaches, and frequently overlaps them. In the beaches large boulders are found, and marine shells, of which lists for the various localities are given. The 'Head' frequently shows rough stratification of finer and coarser materials. It contains *mammalian bones, land-shells* only, and occasionally flint implements. On the coasts of Devon and Cornwall it is separated from the Raised Beaches by old sand-dunes.

In South Wales the beach occurs below the mammaliferous cave-deposits, whilst material corresponding to the 'Head' seals up the cave-mouths. The ossiferous breccias of the caves are therefore intermediate in age between the beaches and the 'Head.'

The origin of the boulders is discussed, and it is inferred that they have been brought, not from the French coast, nor from a submerged land, but from a north-easterly source by floating ice through the Straits of Dover. The mollusca of the Raised Beaches, of which a list of 64 is given, are closely related to forms living in the neighbouring seas.

These Raised Beaches are not of the age of the Higher Valley-gravels; but the evidence (especially that yielded by the Somme Valley deposits) points rather to their connexion with the Lower Valley-gravels, and therefore, with the exception of the Caves, they represent the latest phase of the Glacial Period.

2. "The *Olenellus*-Zone in the North-West Highlands." By B. N. Peach, Esq., F.R.S.E., F.G.S., and J. Horne, Esq., F.R.S.E., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

In the stratigraphical portion of this paper brief descriptions are given of certain sections in the Dundonnell Forest, from eight to ten miles N.N.E. of Loch Maree, which have yielded fragments of *Olenellus*. The organisms are embedded in dark-blue shales occurring near the top of the 'Fucoid Beds' and towards the base of the 'Serpulite Grit,' forming part of the belt of fossiliferous strata stretching continuously from Loch Eriboll to Strome Ferry—a distance of ninety miles.

In the Dundonnell Forest the basal quartzites rest with a marked unconformability on the Torridon Sandstone. There is an unbroken sequence in certain sections from the base of the quartzites either to the 'Serpulite Grit' or to the lowest bands of the Durness Limestone. At these horizons the strata are truncated by a powerful thrust, which, at Loch Nid, brings forward a slice of Archæan rocks with the Torridon Sandstone and basal quartzite.

The strata from the base of the quartzites to the base of the Durness Limestone, exposed in the Dundonnell Forest, are compared with their prolongations to the north and south of that region, from which it appears that there is a remarkable persistence of the various subzones identified in Assynt and at Loch Eriboll. But between Little Loch Broom and Loch Kishorn dark-blue shales near the top of the 'Fucoid Beds' have been observed at various localities, evidently occupying the same horizon as the *Olenellus*-shales in the Dundonnell Forest.

The Serpulites (*Salterella*) associated with the Trilobites in the 'Serpulite Grit' occur in the basal bands of the overlying limestone; they were found during last season in the brown dolomitic shales accompanying the *Olenellus*-shales in the 'Fucoid Beds,' and they were formerly detected in the third subzone of the 'pipe-rock' in Sutherland. Their appearance on these horizons leads us to cherish the hope that portions of *Olenellus* may yet be met with in certain shales in the quartzites and probably in the lowest group of limestone.

The evidence now adduced proves (1) that the 'Fucoid Beds' and 'Serpulite Grit' are of Lower Cambrian age, the underlying quartzites forming the sandy base of the system; (2) that the Torridon Sandstone, which is everywhere separated from the overlying quartzites by a marked unconformability, is pre-Cambrian.

The *Olenellus* which has been discovered is described as a new species (*O. Lapworthi*) closely allied to *O. Thompsoni*, Hall, from which it differs chiefly in the arrangement of the glabella-furrows and in the presence of a rudimentary mesial spine at the posterior margin of the carapace. Remains of other species referable to *Olenellus* are described, but these are too fragmentary for exact determination. All are characterized by a reticulate ornamentation similar to that described by Walcott in *O.* (*Mesonacis*) *asaphoides*, Emmons. The remains consist chiefly of portions of carapaces.

CORRESPONDENCE.

CONE-IN-CONE STRUCTURE.

SIR,—In the present February No. of the GEOLOGICAL MAGAZINE, Mr. A. C. G. Cameron in his paper on the "Kellaways Beds" makes reference to an indurated seam of sandy marl that exhibits Cone-in-cone Structure, and refers to an abstract in GEOL. MAG. of a paper of mine, that is printed in Trans. Geol. Soc. of Glasgow, in which I give an explanation of the above-mentioned structure. In this paper I am credited by Mr. Cameron with stating that in cone-in-cone structure, the apices of the cones point towards each other in the beds in which this structure is found. Had Mr. Cameron read the full text of my paper, he there would have seen that this statement was not mine, but was given in two of the quotations, illustrating some of the views formerly held by those that had written on cone-in-cone structure. Thus, H. C. Sorby, F.R.S., is quoted as having written—"The cones often occur in bands parallel to the stratification of the rock, their apices starting from a well-defined plane, and after extending upwards or downwards for a greater or less distance with their axis perpendicular to the plane of stratification, they end in bases parallel to it but not on the same level, some standing up above the general surface." The other quotation is from the Students' Manual of Geology, by Prof. J. B. Jukes, edited by Prof. A. Geikie, 1872. It is there stated that "some clay ironstones exhibit another concretionary form called 'cone-in-cone,' as the seam of ironstone breaks into conical forms, with the bases of the cones at the top and bottom of the seam, and their apices pointing inwards towards each other."

In my paper I have written against this statement, in both quotations, of the cones ever having their apices pointing inwards towards each other, and state, "I am inclined to think that such a description is due to faulty observation, or could only have been made from a badly preserved specimen, in which the structure was obscure or much confused." I also further state, "that the apices are invariably turned to the under or lower side of the stratum, while their bases are as invariably directed to the upper surface."

In my explanation of cone-in-cone structure, I point out that it was probably due to a mechanical action, set up through chemical agencies, such as gases, that were generated by the decomposition of the organic matter present in the lower portion of the stratum, the elevatory power of such gases, as they escaped upwards to the surface of the bed, through the tube forming the central axis of each cone, brought up from below the successive layers of plastic mud, of which the cone structure is seen to be built up.

HUNTERIAN MUSEUM, UNIVERSITY GLASGOW, JOHN YOUNG.
February 13th, 1892.

READE'S THEORY OF MOUNTAIN BUILDING.

SIR,—In reply to Mr. Reade I am quite aware that he replied to Mr. Davison's argument last year, but in the opinion of good physicists that reply was no answer. Mr. Reade apparently failed to realize Mr. Davison's meaning, and the further explanation given in the postscript to my paper does not seem to have made it clearer to him.

My own ideas of the result of subsidence do not form the primary question in debate, which is—can we accept Mr. Reade's ideas? It is eminently desirable, therefore, that he should address himself to Mr. Davison's objection and postpone any consideration of my criticisms.

I am obliged to Mr. Reade for pointing out the error in my figures; an 0 has been omitted, but when supplied makes the case against him ten times worse than before. If I have misunderstood Mr. Reade's idea of expansive compression, or if my argument is unsound, I shall be glad to be corrected. A. J. JUKES-BROWNE.

EXETER, *Feb.* 10.

CONCERNING THE DIMENSIONS OF OLENELLUS.

SIR,—In his excellent paper "On *Olenellus Callavei*," in the GEOL. MAG., Dec. 1891, p. 529, Professor C. Lapworth says: "The larger fragments collected indicate a length of about six inches and a breadth of about four inches. With the exception of *Olenellus (Holmia) Bröggeri*, Walcott, this form is the largest species of the genus yet discovered." Prof. Lapworth seems to have overlooked that *Olenellus (Holmia) Kjerulfi*, Linns., might reach fully the length of *O. (H.) Callavei*. In my paper "On *Olenellus Kjerulfi*," in Geolog. fören. förhandl. vol. ix. (1887) p. 512, I have stated that: "The largest specimen I have found has a breadth of 63 mm. between the eyes." The length of the body must, therefore, in this case, have been 155 mm., which is more than six inches.

GERHARD HOLM.

OBITUARY.

THOMAS ROBERTS, M.A., F.G.S.,

ST. JOHN'S COLL., CAMB.; ASSISTANT TO THE WOODWARDIAN PROFESSOR.

BORN 1856. DIED JAN. 24TH, 1892.

MR. ROBERTS must have been a strong man to have come to the front as he did; for he had not the early advantages that the youths of our large towns generally have now in the way of lectures and schools and colleges, open to any boys who show a spark of intelligence.

His father was a contractor and agent in Wales, and at one time much better off than the ups and downs of the world left him in his old age. Tom Roberts was intended for the same line, and thus in early life was familiar with the construction of sea-walls, with laying railway lines, with building, and with the superintendence of quarries and mines.

Perhaps this influenced his choice of subjects in after-life. However that may be, he went to school, and showed such promise that he was encouraged and aided to pursue his studies in the University College of Wales at Aberystwith, where he obtained a scholarship for Mathematics. Here also he impressed his teachers with his power, and he was sent up to St. John's College, Cambridge, where he won a scholarship on entrance, and, being now able to throw himself entirely into the congenial study of Natural Science, at the end of his course he was placed in the First Class in the First Part of the Natural Sciences Tripos in 1882, and also in the First Class in the Second Part of the Natural Sciences Tripos in June, 1883.

In the spring of 1883 he was appointed Assistant to the Woodwardian Professor, in succession to Mr. E. B. Tawney, a post which he has held ever since.

It may be asked why a man of such knowledge did not do more original work, but the answer is easy. In the first place his time and energies were chiefly given up to educational work, and secondly he was preparing for a much larger undertaking, namely, a treatise on Palæontology, so that he had no time to keep himself before the public by frequent small descriptions or controversial papers. Moreover, such time as he had to spare was at everybody's disposal. His work must be listened for in echoes rolling on through other people's publications, and the record must be looked for, not in the Proceedings of Societies, but among the hundreds of students that have passed through the Woodwardian Museum since he first took his share in its management and in its educational work.

But if his published work was not voluminous, it was good. He was a stratigraphical palæontologist of a very high order, and those who had the good fortune to work with him in the field will remember how careful he always was to work out the fossils of each zone, and how he allowed no correlation which was not supported by palæontological evidence.

We pass quickly over the joint paper by Marr and Roberts on the

Lower Palæozoic Rocks of the neighbourhood of Haverfordwest,[1] because in that he was associated with the keenest stratigraphical palæontologist we have, on ground which he, rather than Roberts, has made peculiarly his own. Whatever Roberts's contribution to that work may have been, he must have come out of it a stronger man from the contact. But in his description of the Jurassic Rocks, we see in one paper after another first that careful working out of zones in one connected set of sections, and then suggested correlation of horizons between more or less widely separated areas.

He first undertook the examination of the Jurassic Rocks of the neighbourhood of Cambridge, upon which he wrote an essay, for which the Sedgwick Prize was awarded to him in 1886. It was hoped by his friends and by himself, that this essay would some day be expanded into a much larger work, or at any rate that its scope might be considerably extended. As it stands, it is a valuable contribution to the Life History of the Earth, and, for students of the geology of the neighbourhood of Cambridge, a useful handbook. The Syndics of the University Press have undertaken to publish it, and many friends have volunteered their services to help to see it through the press *in Memoriam.*

In the following year he read a paper before the Geological Society,[2] "On the Correlation of the Upper Jurassic Rocks of the Swiss Jura with those of England." This was the outcome of an excursion for which he received a grant from the Worts Fund in 1884. In it he gives a detailed description of the more important subdivisions above the horizon of our Kellaways Rock, with numerous sections, and full lists of fossils. He points out that the thick clays of Kimeridge and the variable beds of Portland and Purbeck are in the Jura all represented by massive limestones and that, as might be expected from such difference of sediment, there is a considerable difference in the fauna of the two areas, but that still some well-marked zones make an approximate correlation possible. The views of various authors and his own as to the identity of certain widely separated zones, he presents tabulated in parallel columns for easy reference, and explains wherein he differs from the continental geologists as to the synchronism or the grouping of the several deposits.

In 1888 the Lyell Fund was awarded to him in token of appreciation of these investigations. Having thus prepared himself for the recognition of the different horizons in the Jurassic Rocks, even when presenting very various aspects, he turned his attention to "the Upper Jurassic Clays of Lincolnshire,"[3] and traced through that district a zone which had not been previously recognized, and which he identified with certain clays in the neighbourhood of Cambridge, referred by him to the Corallian.

The thorough way in which he worked out a palæontological inquiry may be gathered from his early note[4] on what he considered a new species of *Conoceras* from Llanvirn. He described the specimen and its state of preservation, pointing out sources of error arising from confounding superinduced structures in the rock, with original markings on the organism. He compared it with those species which appear most nearly to resemble it among previously described forms. He pointed out the exact geological horizon from which it was obtained, as determined by the associated fossils, and then gave the technical description of his new species.

---

[1] Q.J.G.S. vol. xl. 1884, p. 476.

[2] Q.J.G.S. vol. xliii. 1887, p. 229.

[3] Q.J.G.S. vol. xlv. 1889, p. 545.

[4] Q.J.G.S. vol. xl. p. 636.

The same treatment of the specimens and of the species is seen in his description[1] of "Two Abnormal Cretaceous Echinoids."

In Palæontology also we must look for his work not so much in published descriptions of new species, as in the large numbers of named fossils in the Woodwardian Museum, from almost every horizon, the determination of which we owe to him.

The characteristic of his work as of the man was its honesty. We who lived and worked with him up to a few days of the end feel his loss at once; he is no longer there to help, and many another coming up to the old Museum from time to time will feel it too; for when a friend or stranger asked to see something in our collections, we would say, "You will find Tom Roberts there," with full confidence that our visitor would return well pleased and the honour of our Museum would be well sustained.

He was a man of great force of character, of clearness of vision, and soundness of judgment. False reasoning rarely escaped him, and you could no more lose sight of his intellectual presence than of his large and powerful frame. Yet his gentle sympathetic manner and his open truthful eye gave you at once the comfortable feeling that you need not be on your guard with him. Students said that he never tried to put himself on a higher pedestal by scoring off them. He led them on, and rather than drive or urge them, he would ask them to help him to get them through with credit, as if he, not they, were most interested in their success.

T. McKenny Hughes.

FREDERICK DREW, F.G.S., F.R.G.S.

Born August 11, 1836. Died October 25, 1891.

Mr. Frederick Drew, F.G.S., F.R.G.S., was born August 11th, 1836, at Southampton, where his father kept a well-known private school, and at this school he was educated until he was seventeen years of age, when he entered the Royal School of Mines, at that time (1853) recently established in connexion with the Jermyn Street Museum. Here he distinguished himself, although younger than some of the other students, by taking all the prizes offered, including the Duke of Cornwall's Scholarship, a Royal Scholarship, and the Edward Forbes medal, the last two for the first year in which they were awarded.

In 1855, on leaving the School of Mines, Frederick Drew joined the Geological Survey of Great Britain, and remained on the staff till 1862, being chiefly engaged in the south-east of England. His principal contributions to science during these seven years included an important paper on the Hastings Sands, published in the Quart. Journ. Geol. Soc. for 1861, and an account of the Geology of Folkestone, Rye, and Romney Marsh, which appeared in the Geological Survey Memoirs. The subdivisions of the Hastings Sands proposed by Drew have been accepted by the Survey and by British geologists generally, and he introduced some modifications of much value in the classification of the Lower Cretaceous beds throughout the Wealden area.

---

[1] Geol. Mag. Vol. VIII. 1891, p. 116.

In 1862 the Maharaja of Kashmir desired to have the services of a geologist to report on the mining wealth of his country, and the appointment was accepted by Drew, who remained for ten years in Kashmir. At first he was, nominally, engaged in mining research; naturally the ideas of an Indian Maharaja and those of a European geologist as to the methods and objects of such inquiries would differ materially, and it is not only highly creditable to Drew, but rather remarkable that, despite the inherent difficulties of his position, he should have impressed the Maharaja and his advisers so favourably as to be appointed first to the governorship of Jummu, and subsequently to the still more important one of Ladák. There can be no question that his skill and tact in dealing with natives of India, and his even temper and coolness in emergency, led to his being entrusted with the important posts that he filled.

The principal results of his residence in Kashmir, and of the exceptional opportunities he enjoyed for seeing the country and its inhabitants, were communicated to the public in his well-known work on Jummu and Kashmir, published in 1875.[1] The greater part of his geological observations were necessarily reported to the Kashmir Government alone, but some purely scientific notes on the alluvial deposits that occupy so enormous an area in the Upper Indus Basin, as in other parts of Central Asia, were communicated by him to the Geological Society.[2] A large portion of this paper is an account of the physical geography of the country, and describes the land contours and their mode of origin in Ladák and other parts of Kashmir territory, whilst the work on Jummu and Kashmir is a storehouse of geographical and ethnological data, of which later writers have frequently had occasion to avail themselves. The work is well written and extremely interesting. An abridged edition was published by the author in 1877, under the title of "Northern Barrier of India."

The only communication to the publications of the Royal Geographical Society that appeared from Drew's pen was his description, in a letter to Sir Roderick Murchison, of the steps taken, under instructions from the Maharaja of Kashmir, to ascertain the circumstances attending the murder of Mr. Hayward, the well-known explorer of the countries lying north of Kashmir. Mr. Hayward, who was a medallist of the Royal Geographical Society, was killed when on his road to the Pamir, by Mir Wali of Yassin, chiefly, it appears, for the sake of plunder. The whole of the circumstances were ascertained by Drew, and an unfounded suspicion that at one time existed against the Kashmir Government was dispelled.

---

[1] The Jummo and Kashmir Territories, a Geographical Account. By Frederick Drew, F.G.S., F.R.G.S., Assoc.R.S.M. London, 1875. 8vo. pp. xvi. and 568. 8 folding maps and sections, and 34 illustrations.

[2] Quart. Journ. Geol. Soc. vol. xxix. 1873, pp. 441–471.

After returning to England in somewhat enfeebled health in 1872, Drew was for some time unemployed, and he devoted his leisure to the preparation of his book on Jummu and Kashmir, upon which his reputation for the future must mainly depend. In 1875 he accepted a mastership at Eton, and remained in the college until his death. The duties of his post required constant attendance, and for the last few years he has been but rarely able to take part in the meetings of any of the London scientific societies. He was, however, too widely known, and too generally esteemed by his old friends of the School of Mines, the Geological Survey of Great Britain, the Geological Society, and the Royal Geographical Society, as well as by those who knew him in Kashmir, to be forgotten, and it is a matter for deep regret that his untimely death has prevented his taking that position amongst scientific men in London for which his talents, his knowledge, his tact, and pleasing manners pre-eminently qualified him.[1]

Mr. Drew was elected a Fellow of the Geological Society in 1858, and of the Royal Geographical Society in 1872.

MISCELLANEOUS.

William Smith, L.L.D., "The Father of English Geology."

Prof. Judd has called attention to an error, often copied from "The Life of William Smith," by his nephew, the late Professor John Phillips, F.R.S., of Oxford, in which it is stated that "his bust, surmounting the tablet to his memory, is in the beautiful antique church of *All Saints*, at Northampton, where his remains lie buried" (see Geol. Mag. for Feb. 1892, p. 95). William Smith lies buried a few feet from the west tower of the fine old Norman church of Saint Peter's at Northampton. The bust is placed within the church, against the west wall of the nave, south of the grand Norman arch over the entrance to the tower. It stands on a marble pedestal inscribed:—

"To honour the name of William Smith, LL.D. This monument is erected by Friends and Fellow-labourers in the field of British Geology. Born 23rd March, 1769, at Churchill in Oxfordshire, and trained to the Profession of a Civil Engineer and Mineral Surveyor, He began, in 1791, to survey collieries and plan canals in the vicinity of Bath, and having observed that several strata of that District were characterized by peculiar groups of organic remains, he adopted this fact as a principle of comparison, and was by it enabled to identify the strata in distant parts of this Island, To construct sections, and to complete and publish in 1815 a Geological Map of England and Wales. By thus devoting, during his whole life, all the power of an observing mind to the advancement of one Branch of Science, he gained the title of the 'Father of English Geology.' While on his way to a Meeting of the British Association for the Advancement of Science at Birmingham, he died in this town, at the house of his friend George Baker, the historian of Northamptonshire, 28th August, 1839.[2]

---

[1] From Proc. Roy. Geographical Society, vol. xiv. No. 1, January, 1892, p. 52–54, by W. T. Blanford, LL.D., F.R.S.

[2] I am indebted to the Rev. E. N. Tom, M.A., Rector of St. Peter's, Northampton, for the above transcript. There is no sculptor's name on the bust.—H. W.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IX.

No. IV.—APRIL, 1892.

ORIGINAL ARTICLES.

I.—Preliminary note on the Sequence and Fossils of the Upper Triassic Strata of the Neighbourhood of St. Cassian, Tyrol.

By Miss Maria M. Ogilvie, B.Sc. (Lond.).

DURING the past autumn, at the kindly suggestion of Prof. Baron von Richthofen, I spent some months in the study of the strata and fossils of the neighbourhood of St. Cassian. My object was to endeavour, if possible, to determine the most natural subdivisions of these classic strata, and to fix their characteristic fossils. As the results I have obtained are somewhat novel, and may prove of interest to those who are familiar with the enigmatical character of the stratigraphy of the beautiful region of the Dolomites, I may, perhaps, be permitted to give in this place a short summary of my conclusions, in anticipation of a detailed paper upon the subject.

In 1860, von Richthofen[1] published the first detailed examination of the Triassic strata in South Tyrol; and in this work he sought to explain the geological features of the Upper Trias by application of Darwin's theory of the conditions attending the growth of Coral-reefs. In the well-known work of Mojsisovics ("Die Dolomit-Riffe von Süd-Tirol und Venetien," Wien, 1879) the Upper Triassic strata of the region are grouped in five main divisions in ascending order.

Upper Trias.
Noric Strata = 1. *Buchenstein* Beds. 2. *Wengen* Beds.
Karnic Strata = 3. *Cassian* Beds. 4. *Raibl* Beds. 5*a*. *Dachstein Kalk* (in part).
Rhætic strata = 5*b*. *Dachstein Kalk* (in part).

This succession of Upper Trias is but slightly modified from Richthofen's; one main point of difference is that Richthofen places between the Cassian and Raibl Beds the *Schlern Dolomite*, which he holds (1) to be younger than the Buchenstein, Wengen, and part of Cassian strata, and (2) in some cases to rest unconformably, as at Schlern mountain, on Mendola Dolomite (Muschelkalk); (3) to be of local occurrence. Mojsisovics, on the other hand, states that the three groups of the Buchenstein, Wengen, and Cassian Beds are *normally* stratified, but that *all three are locally* represented by massive non-stratified dolomitic reefs of the same age. He draws attention also to the appearance of thinner lenticular beds of dolomite at any horizon in the Wengen and Cassian strata.

---

[1] Geognostiche Beschreibung der Umgegend von Predazzo, Sanct Cassien und der Seisser Alpe in Süd-Tyrol. 4to. Gotha.

Both Richthofen and Mojsisovics are of opinion that the Cassian and Raibl beds with their characteristic faunas are essentially of limited occurrence, having been deposited in occasional lagoons and quiet bays.

My personal mapping of the stratified deposits near St. Cassian and at Seeland Thal and Cortina has enabled me to show that a further subdivision of the Wengen and Cassian strata is possible and necessary; and the detailed study of the rocks and fossils makes it clear that each of these proposed subdivisions is distinguished by both lithological and palæontological characters peculiar to itself. The most natural grouping of the strata seems to me to be as follows in descending order:—

	DACHSTEIN KALK		A greyish-white dolomite, rarely limestone; the rock is stratified, and usually of compact character. *Megalodon triquetus* (Wulf.).
	RAIBL BEDS.		Dolomitic breccias, bituminous limestones, sandstones, beds of gypsum, pure dolomite, and variegated ferruginous clays. Fossils: *Ostrea montes-caprilis* (Klipstein), *Myophoria Kefersteinii* (Goldf.), *Corbis Mellinghi* (Hauer), etc.
'Cassianer Strata,' and contemporaneous 'Cassianer dolomite,' (Mojsisovics).	SCHLERN DOLOMITE		A dolomite of drusy, highly crystalline character; fossils rare; corals, encrinites, bivalves.
	CASSIAN BEDS.	*Upper Cassian* *or* *Prelongei zone.*	Fossiliferous marls, dark clays, light grey shales and interstratified limestones. *Montlivaltia crenata* (Münst.), *Cladophyllia subdichotoma* (Sube.), *Anoplophora Münsteri* (Wissm.), *Avicula Gea*, d'Orb.
'Wengener strata' and the contemporaneous horizon of 'Wengener Dolomite' (Mojsisovics).		*Middle Cassian* *or* *Muren zone.*	Marls, impure clays and shales with interstratified oolitic sandstones and limestones, and beds of arragonite, the whole series showing admixture of volcanic mud. Fossils few: *Mytilus Münsteri* (Klipst.), Encrinites, also plant-remains.
		Lower Cassian *or* *Stuores zone.*	Dark fossiliferous marls and clays and interstratified beds of hard fossiliferous limestone. *Isastræa Gümbeli* (Laube.). *Nucula lineata* (Goldf.), *Cassianella decussata* (Münster), *Koninckia Leonhardi* (Wissm.), *Terebratula indistincta* (Beyrich).
	WENGEN BEDS.	*Up. Wengen.*	—Breccias (composed of limestone and volcanic material), thin-banded limestones and clays, thick beds of brownish sandstone—arragonite beds. *Posidonomya Wengensis* (Wissmann), *Trachyceras furcatum* (Münster).
		Lr. Wengen.	*b.* Tufaceous sandstones & impure limestones; black eruptive tuffs with or without augite porphyry. *Daonella Lommeli* (Wissm. sp.), and plant-remains (*Equisetites*, etc.) *a.* Halobia shales, *Daonella Lommeli* (Wissm. sp.) (of local occurrence).

……

Horizon of the 'Buchensteiner beds and B. dolomite' (Mojs.).	Augite porphyry or volcanic series, and Buchenstein strata.

……

Below come the equivalents of the Muschelkalk, which lay outside the sphere of my researches.

There is no great difficulty is establishing this detailed sequence, as the beds between the Buchenstein strata and the Dachstein are exposed in good sections; each zone is individualized by its own lithological features and the characteristic fossils were collected on the ground. There is a replacement of older by newer forms in passing upwards; but no recurrence. The two great calcareous dolomitic series—the Schlern-Dachstein above and the Muschelkalk below—are separated over a large district by the entire non-dolomitic series, and even the well-known Cipit limestones prove themselves to be constant Coralline zones in the Cassian period.

In determining the limit of Wengen and Cassian strata, I wished to emphasize the first appearance in Triassic time of the varied and highly characteristic fauna of St. Cassian. In this respect my mapping differs in many places from that of Mojsisovics, *e.g.* in the typical St. Cassian district the Cassian strata are limited in the map of Mojsisovics to the Prelongei heights, and correspond generally to the "Upper Cassianer Strata" in the succession given above. At the same time Mojsisovics mentions in his text that the Cassian fossils are found on both the Stuores and Buchenstein slopes of the Prelongei ridge. These slopes, from which the main part of the Cassian fossils are derived, I have mapped as Middle and Lower Cassian strata. Again, on the Seisser Alpe, Mojsisovics maps no Cassian strata, preferring to regard the fossils in Cipit Alpe, etc., as being of Wengen age, although remarking that they resemble the later Cassian fossils. In other places, his so-called "Riff-Kalk," or "Cipit-Kalk," is said to thin out in Wengen strata or in Cassian strata. The "Riff-Kalk" contains Cassian fossils, and is of Cassian age.

By means of the above subdivisions, and certain zones in these, I have also found it possible to show that the district is cut up by many dislocations which could not previously have been traced through the Wengen and Cassian strata; but this part of my work is not yet finished. Another fact which appears is that the Raibl strata lie always above the Schlern Dolomite, and that they are different in character, and stratigraphically separated from, the Cassian strata, which invariably lie below the Schlern Dolomite. This has a distinct bearing on the much-discussed question of the "*Cardita strata*" in the North Alps. In the carefully-worked sections of N. or Bavarian Alps the "*Upper Cardita*" Beds are proved to be Raibler strata resting upon "Wetterstein Kalk," while the *Partnach strata*, which afford Cassian, Wengen and Buchenstein fossils, underlie the Wetterstein Kalk.

II.—ON THE OCCURRENCE OF A NEW FORM OF *DISCINOCARIS* IN THE GRAPTOLITIC BEDS OF THE "COLONIE HAIDINGER" IN BOHEMIA.

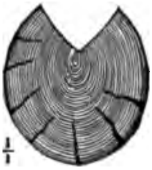
By Professor OTTAMAR NOVÁK.

IN the Quart. Journ. Geol. Soc., vol. xxxvi. 1880, p. 617, Mr. John E. Marr mentions having examined three specimens of a Phyllopodiform Crustacean discovered by Mr. Martin Dusl in the strata of "Colonie Haidinger," situated not far from the village of Gross-chuchle, south of Prague.

The specimens were then identified with *Discinocaris Browniana*, H. Woodw., figured and described in the same Journal, vol. xxii. 1866, p. 503, pl. 25, figs. 4, 5, and 7. They are also mentioned by Dr. H. Woodward and Prof. T. Rupert Jones in the Third Report of the Committee on the Fossil Phyllopoda of the Palæozoic Rocks, 1885, p. 2, under Mr. Marr's specific determination.

Having worked for some time past on a revision of the fossil Phyllopoda occurring in the Palæozoic rocks of Bohemia, I examined the three specimens in Mr. Dusl's collection, besides two others collected by myself in the same beds some years ago.

The following figure and description give sufficient evidence of the characters of the fossil in question.



Discinocaris Dusliana, Novák. Nat. size.
In the Geological Museum of the Bohemian University at Prague.

Description.—The shield flattened, oval in outline, without any median suture, but truncated in front by a nuchal notch, leaving a broad re-entrant angle, with rather concave sides and with an apex reaching about one-third of the shield's original length. Width of the nuchal notch precisely one-sixth of the entire circumference. Surface finely striated; the striæ disposed excentrically round about the apex of the frontal notch. The triangular frontal piece wanting in all five specimens under examination. The shield, if complete, would be about 22 mm. long, 19 mm. broad. The total length from the apex of the notch to the posterior margin being 15 mm.; slope of nuchal suture about 45°.

The superficies of the shield seems to have been originally somewhat convex, but appears to have been flattened by forcible compression, as indicated by the radiate fissures in our Woodcut.

It is evident that the carapace just described represents a new form of *Discinocaris*, for which I propose the specific appellation of *D. Dusliana*, after Mr. Dusl, who first drew attention to the fossil.

Discinocaris Browniana, H. Woodw., differs from the Bohemian species, firstly, by its circular outline; secondly, by the nuchal notch reaching backwards nearly to the centre of the carapace; thirdly, by the different slope of the nuchal suture.

The fauna of the "Colonie Haidinger" shows the same composition as the lowest Graptolitic horizon of stage E—e 1. The most common fossils of this "colony" being *Monograptus Becki*, Barr., and *Rastrites peregrinus*, Barr.

Having no sufficient materials, I will not discuss the question if the shields called *Discinocaris* should be regarded as opercula of Cephalopods or carapaces of Phyllopodiform Crustaceans; but it must be remarked that no trace of Cephalopods has yet been discovered in the "Colonie Haidinger."

III.—A NEW BRITISH PHONOLITE.

By FREDERICK H. HATCH, PH.D., F.G.S.

(By permission of the Director-General of the Geological Survey.)

IN working out, at the request of Sir Archibald Geikie, the petrography of the Lower Carboniferous Volcanic rocks in Haddingtonshire (the results of which I propose shortly to publish), I have been led to examine the igneous material that builds up the isolated hills (*necks*), situated on the margin of the volcanic area of the Garlton Hills. Among these, the rock of Traprain Law especially attracted my attention. It is a close-grained, dark brown to grey rock. Some varieties have a glistening or greasy surface, and are speckled over with dark spots, while others show glancing cleavage surfaces of a clear glassy felspar (sanidine).

The stone is quarried at the foot of the hill. On examining the broken material in the quarry, I noticed a tendency to split into rather thin plates. This "platy fracture," taken in conjunction with the fact that the stone has a remarkably sonorous ring under the hammer, and gives a metallic clink when small fragments are rattled together, might perhaps have suggested its real nature. But it was not until I had studied a series of thin sections that the true character of the rock became apparent, Microscopic examination shows that the rock is a *trachytic phonolite*, and thus adds another to the sparsely developed nepheline-rocks of the British Isles.

As I intend to describe this occurrence more fully elsewhere, I will confine myself in this place to a brief description. The rock bears no resemblance to the well-known phonolite of the Wolf Rock, described by Mr. Allport in 1871. It differs from that rock in the absence of members of the hauyn-nosean group, and by an inferior development of nepheline.

Instead of occurring in clearly discernible crystals, as in the Cornish rock, the nepheline of the Traprain Law phonolite is confined to small colourless to cloudy patches, or is interstitially wedged in between the felspar-lathes of the ground-mass. The satisfactory identification of nepheline when thus developed is the source of much trouble and vexation of spirit. Taking refuge in micro-chemical methods, I found that a drop of hydrochloric acid, placed on a smooth surface of the rock, rapidly produced gelatinization, and that the jelly, when dried and treated with acetate of uranium, developed abundant characteristic crystals of the double acetate of uranium and sodium. The presence of a sodium-bearing mineral in the rock was thus placed beyond doubt. By treating a section with hydrochloric acid, and staining with fuchsine, after washing off the acid, the nepheline-patches were fairly well defined. Finally, to make quite sure of the matter, I sent a specimen of the rock to Professor Rosenbusch, of Heidelberg, who was good enough to have a very thin slice prepared, in which he succeeded in detecting the presence of small four- and six-sided sections of nepheline. Prof. Rosenbusch confirms my diagnosis of the rock, and refers it to the trachytoid division of the phonolites in his classification (*Physiographie der massigen Gesteine*, vol. ii. p. 622).

The main portion of the rock is made up of small lath-shaped crystals of sanidine, presenting in their mode of arrangement a marked micro-fluidal structure. Porphyritic crystals of sanidine also occur, but not very frequently. The only other constituent of any moment is a green augite giving high extinction angles. The presence of aegirine has not been detected. Apatite and sphene also occur in isolated granules. In the nepheline-patches the alteration of that mineral has given rise, as usual, to the formation of zeolites (analcime and natrolite).

GEOLOGICAL SURVEY OFFICE, 28, JERMYN STREET, S.W.
Feb. 20th, 1892.

IV.—DRIFT COAL IN SANDSTONE.

By G. W. BULMAN, M.A.,
Corbridge-on-Tyne.

THE most exclusive advocates of the hypothesis of the terrestrial origin of Coal admit that those small irregular patches, veins, and nests of the same occurring in beds of sandstone are formed of drift vegetation. And admitting this, it is difficult to draw the line until we have ascribed a similar origin to certain definite coal seams of considerable extent. Granting this much, however, is obviously a different thing from the belief that *all* coal seams are to be ascribed to drift vegetation; and while the following remarks are intended to show what a strong argument such drift coal in sandstone furnishes for the *probable* drift origin of *certain* coals, there is no intention of ascribing such an origin to *coal in general.*

Such drift coal in sandstone is of very common occurrence in the Coal-measures, and good examples are to be seen in the coast-section of the Northumberland coal-field. It seems strictly analogous to those similar patches of shale which are also common in sandstone, and the same origin must be ascribed to both.

The explanation in the case of the shale is, that the currents which brought the coarser material of the sandstone failed at intervals, and that consequently the finer sediment—which would otherwise have been carried further and laid down by itself—was allowed to settle in hollows among the coarser, and was in turn overlaid by it when the currents regained their force. And we must suppose the same currents brought down vegetable matter, which, when their force failed, might be laid down among the coarser sediments, and would at other times be carried beyond and laid down by itself. The obvious inference is, that, as beds of pure shale are due to the same drift origin as the fragmentary patches in the sandstone, so, if we allow a drift origin for the fragmentary coal, we must also admit the probability of the accumulation of *beds* of pure vegetable matter by the same agency.

But as in the case of shale we find every gradation between included fragments in sandstone or shaly sandstone, and strata of pure shale, so—if the origin is the same—should we find a similar series of transitions in the case of coal. And such is, in fact, the case. For, as we have shaly, so we have carbonaceous, sandstones; and as we have shales intercalating with, and occurring as isolated masses of considerable extent in, sandstone, so we find it also in the case of coal.

In the Survey Memoir of the Yorkshire Coal-field some good examples of the complicated intercalations of shale and sandstone are given (see pp. 73 and 94). These are similar to the intercalations of coal and sandstone in connexion with one of the "rock faults" described and figured in the Memoir of the South Staffordshire Coal-field.

Reference to the sections (figs. 4 and 5) given on pages 184 and 185 of this latter Memoir shows the intimate connexion of the coal and sandstone. And, as Mr. Jukes remarks, even the minute veins of coal are "perpectly bright good coal." It is difficult to account for this purity combined with intimate intercalation on the theory of growth *in situ*, and the similarity to the intercalations of shale above referred to suggest for the coal a similar origin.

In the Coal-measures of Central France, again, M. Fayol describes numerous examples of the minute intercalations and interlaminations of the coal with sandstone and shale. In their intimate ramifications with the sedimentary deposits these portions of coal seams are strictly comparable to the intercalations of shale and sandstone of the Yorkshire Coal-field, and to the branching of the "Thick coal" in connexion with the "rock fault." And they form one of the arguments which have led M. Fayol to advocate a drift origin for the coal.

Such intercalations of coal and sandstone, then, while they form a difficulty on the hypothesis of terrestrial accumulation, are just what we should expect if we ascribe to the coal an origin similar to what we allow for the shale.

The purity of the coal—even in the thin veins—and its clear lines of demarcation from the sandstone can only be attributed to the sorting power of water; the hypothesis of floods carrying sediment over the edges of the swamp where vegetation was accumulating cannot account for this purity of the thin layers of coal; for the growth of vegetation after each flood would necessarily mingle itself with the mud, and be in turn thoroughly permeated by that brought down by the next. But, admitting the drift origin of these intercalations, it follows that the "Thick coal" itself, of which seam they are portions, must be attributed to a similar origin.

Coal-seams may also be broken up by intercalated bands of sandstone, as in the following section of the "Kailblades" Coal of the Midlothian Coal-field:

	Feet.	Inches.
Sandstone and Shale	10	8
Coal	1	6
Sandstone	2	11
Coal	1	1
Sandstone and Shale	3	2
Coal	1	10
Sandstone and Shale	78	1

(Memoirs Geological Survey, Geology of the Neighbourhood of Edinburgh, p. 97.)

Similarly thin seams of coal may occur in beds of sandstone, as in the following section on page 100 of the same Memoir:

	Feet.	Inches.
Grey Sandstone	62	0
Coal	0	3
Sandstone	3	0

There are, moreover, certain areas of coal—usually of limited extent—which are attributed to drift vegetation by advocates of its terrestrial origin in general. Thus Prof. Green attributes the origin of cannel coal to the accumulation of drift vegetation in ponds or lakes:—

"The presence of fossil fish in cannels shows that they must have been formed under water, and they probably consist of vegetable matter which has drifted down into ponds or lakes and lay soaking till it became reduced to pulp" (Coal, by Professors Green and Miall, etc., p. 31).

And if it be admitted that the sand, mud, and vegetable matter drifted down by streams into the pond or lake were sorted so as to produce beds of more or less pure coal, is it not necessary also to admit that a similar sorting, on a much larger scale, would take place with the vegetation and other *débris* carried down to the sea?

Thus we are led to admit the possibility of more extensive beds of coal being formed of drift vegetation. Nor is it necessary to assume that such drift coal will necessarily be cannel. For the obviously drift coal we have been considering is not cannel, but ordinary bituminous coal, with the usual cleavage.

If, then, cannel coal—as seems probable—was formed by drift vegetation, and ordinary bituminous coal in sandstone has a similar origin, there seems no reason why areas of the latter as extensive as those of the former, or even more so, should not occur. Such a conclusion, however, leaves unexplained the differences between cannel coal and the ordinary bituminous coal found in sandstone.

Other considerations point to the conclusion that in certain cases ordinary bituminous and cannel coal have been formed under the same conditions as to place.

In the Northumberland Coal-field, for example, no distinct and separate beds of cannel occur; it is only *portions* of seams of ordinary coal which furnish it.

In Scotland, again, a seam of coal 2 feet thick, and lying between two beds of limestone, has the upper 8 in. cannel (Geology of Neighbourhood of Edinburgh, Surv. Mem. p. 55).

It seems the natural conclusion to suppose that the two kinds of coal were formed in the same way.

Cannel coal, again, is found at times resting on an underclay like an ordinary bituminous coal. The well-known "Boghead" cannel, for example, is thus underlaid. And in the sections from the Coal-field of Cape Breton, given by Sir J. W. Dawson, on p. 414 of his Acadian Geology, four seams of cannel coal are given as resting on underclays. The presence of such underclays beneath coal seams is one of the main arguments in favour of the origin of coal *in situ*; and however we interpret it in this case, it is suggestive of a common origin for cannel and ordinary coal *in some cases at least.*

And as coal and shale are both found in irregular strings and patches in sandstone, so coal is found associated in the same way with beds of shale. Thus we find described in the Survey Memoir of the Yorkshire Coal-field "a section of strings of coal in shale about 1 foot long and 1 inch at the thickest, thinning out towards each end" (p. 579). And on p. 519 of the same Memoir we find the following section showing the same phenomenon in underclay:—

	Feet.	Inches.
Coal	3	6
Underclay and *Coal-veins*	0	8
Sandy Underclay	1	6
Sandy Shale...	1	9
Sandstone	2	0
Underclay and *Coal-veins*	4	1

And from this occurrence of veins of coal in underclay to the following section from the same Memoir, where the coal may be said to play the rôle of "partings" in a bed of underclay, is but a step:

	Feet.	Inches.
Coal	0	6
Underclay	4	1
Coal	0	1½
Underclay	2	2
Coal	0	4
Underclay	1	5
Coal	0	3

(High Moor Lane Pit, p. 167.) Between such a section as the above and the average coal-seam, where underclay or other fine-grained rock forms the "partings," the difference is again merely one of degree.

And similar patches and veins of coal are found not infrequently in limestone. Here, again, is coal obviously of drift origin, and as in the previous cases it is pure, bright, cleaved coal like that of the ordinary seams of the Coal-measures.

The fragments of coal in limestone lead to the consideration of the coal-seams associated with limestone strata, as in the Lower Carboniferous of Northumberland and Scotland. In Northumberland the coal is sometimes directly overlaid by a limestone, and rests with its accompanying underclay on a sandstone. We can scarcely suppose an abrupt transition from terrestrial conditions to those requisite for the formation of limestone; or, in other words, that the sinking area would not pass through the stage where sand and mud would be deposited on the coal. And there is a further difficulty in understanding how the terrestrial surface could be lowered to the requisite stage for the formation of limestone without suffering extensive denudation. A more probable supposition seems to be, that the shallow, near-shore, conditions which allowed the formation of a sandstone gave place gradually to the deeper water in which underclay, coal, and limestone were formed in succession.

Further examples of limestone directly overlying coal-seams may be cited from the Carboniferous Limestone Series of Scotland. Thus, Sir A. Geikie describes a limestone "of a compact bluish-grey texture, with abundant fragments of small encrinites," resting on "an eight or ten inch seam of coal" (Geology of Edinburgh, Surv. Mem. 32 Scotland, p. 48).

Again, a section given on p. 55 of the same Memoir shows a 2 feet seam of coal overlaid by 8 feet of limestone and resting on 3 feet of "Cement"—a kind of impure ferruginous limestone. It is interesting to note that the upper 8 inches of this coal is "Parrot" or cannel coal.

On p. 81 of the same Memoir Mr. Howell describes an exceedingly interesting case in which a coal-seam with its fire-clay occurs between two beds of limestone. The seam is not continuous, and the two beds of limestone sometimes come together.

Such a case would be extremely difficult to explain satisfactorily on the growth *in situ* hypothesis, and it is not easy to resist the conviction that if the limestone was formed in moderately deep water, and some little distance from land, coal and fire-clay were also formed under approximately similar conditions of depth and distance from shore.

On the whole, then, it must be admitted that the occurrence of such fragmentary drift coal as we have been considering furnishes a strong argument that seams of ordinary coal *may, in certain cases,* have had a similar origin.

V.—NOTES ON THE ASH-SLATES AND OTHER ROCKS OF THE LAKE DISTRICT.

By W. MAYNARD HUTCHINGS, Esq.

WHILST studying the sedimentary roofing-slates of North Wales and Cornwall, and allied materials, my attention was also directed to those most interesting rocks, the ash-slates of the Lake District, often externally so closely resembling some of the Welsh and Cornish examples, though differing so much in origin. In course of time I have collected, and had sections prepared from, a considerable number of specimens from many quarries and other places at various parts of the district, both very fine-grained well-cleaved actual roofing-slates and also the attendant coarser beds.

A full understanding of the changes these deposits have undergone, and their present nature, would require a large amount of fuller study, especially in a chemical direction; but some of the results of my observations may be worth recording as far as they go, even if only on the chance that they may perhaps induce some worker, with more time and opportunity at his disposal than I possess, to take up the investigation of these rocks. In the Lake District we have a wonderful field for the petrological microscopist and chemist, which has been singularly neglected, I think, considering the avidity with which petrological work has been taken up of late years.

Perhaps this comparative neglect may be less seen in future, since the paper by Messrs. Harker and Marr on the Shap rocks has shown what splendid work may be done there by competent workers.

If we examine a series of the finer-grained rocks of the district, taking some of those worked as roofing-slates as especially typical, we find considerable variation in texture, corresponding to differences in composition as shown by the microscope. Thus the larger portion of such slates are seen, in thin sections under low and moderate powers, to consist of more or less well-defined and recognizable fragments and grains of various kinds,—lapilli, felspars, calcite, chlorite, etc.,—bedded in and surrounded by varying amounts of a paste, or base, so to speak, which is exceedingly fine-grained. This very fine-grained material increases in some slates till it becomes the sole constituent, while in others it plays only a more subordinate part; but it is always present and always, within certain limits, similar in appearance under the microscope, till we pass over into the coarser-grained ashes and tuffs which are not classed as slates at all.

In order to study the nature of this pervading "base," I will select one or two special occurrences, in which the original nature of the materials from which they have been formed can be ascertained with considerable certainty.

There is an old quarry in the valley of Mosedale, near Shap, in which beautiful examples of these ash-slates occur. Bands of various coarseness of grain succeed one another in narrow limits and pass abruptly into one another, corresponding, apparently, to sudden changes in the condition of the volcanic detritus being deposited. A coarser band, for instance, will consist very largely of good-sized lapilli, sharply outlined and well preserved, formed for the most part of normal andesitic rocks of the district, but with rhyolite also represented, and will contain also many detached crystals and fragments of felspar, with varying amounts of grains of calcite and patches of chlorite.

A succeeding fine band will show none of these lapilli, recognizable fragments of felspar, etc., but consists absolutely of the very fine base which surrounds the lapilli, etc., in the coarser band. We cannot doubt that it represents the alteration-product of the very finest dust of the same materials as make up the coarser band, and therefore that it consisted originally mainly of andesitic and felspathic powder with a little rhyolite *intermixed.*

It is very difficult to make out much as to its exact nature under the microscope; nothing but the very thinnest films are of any use. Taking the thinnest edges of thin sections, or the margins of little holes worn in the last stages of grinding, and studying these carefully with a $\frac{1}{4}$ or $\frac{1}{8}$ objective and good illumination,[1] the most prominent constituent is seen to be a very pale-green chlorite in a felted mass of extremely minute flakelets, mainly arranged flat in the plane of cleavage. In polarized light one sees large numbers of minute rod-like bodies lying in all directions in among the chlorite, strongly bi-refractive, extinguishing quite parallel, their long axes being axes of least elasticity. In ordinary light these rods are not seen at all. There are also countless minute grains of another mineral, mainly so small that, owing to the very high refraction which they possess, they appear as opaque bodies; but larger ones occur with transparent colourless to yellow centres. These grains are so numerous that the whole slide, under low power, seems simply full of a dark dust. The largest grains attain to a diameter of about $\frac{1}{12000}$ inch. By examining such of these larger grains as occur at spots in the slide which remain dark on rotation between crossed Nicols, it is seen that they are isotropic.

On rotating the section in polarized light, the whole appears as a faintly-speckly, cryptocrystalline, felsitic-looking mass, full of the brightly-polarizing minute rods above spoken of, and one suspects that there is some other matter present besides those mentioned, but it is so wholly enveloped in and masked by the chlorite that nothing can be safely made out.

If a thin section is treated alternately with hot hydrochloric acid and solution of caustic potash, the chlorite may be mostly removed; but this operation succeeds better using powdered slate, digesting thoroughly with moderately strong acid, washing free from the dissolved chlorides and treating with hot potash solution to remove separated silica, afterwards mounting the small grains and flakes in balsam. Material so prepared is free from chlorite and reveals much more of its nature. The dark granular matter, enlarging into transparent grains, is still present in the same abundance as before. Its isotropic character is now more easily ascertained. Taking its various characteristics as stated, together with the fact that no amount of boiling in strong acid affects it, there is no reason to doubt that this granular mineral is garnet. It is far too minute to allow of any mechanical separation of it. The brightly-polarizing rods are also present as before, and it may now be made out that they are the transverse sections of minute' flakes of a faintly yellowish to greenish mica, apparently a "sericite" in all respects analogous to the minute mica of the fireclays and sedimentary slates. This mica and the garnets are seen, especially on rotation in polarized light, to be intimately mixed in with some other substance, whose exact nature cannot be determined. There is a very minute mosaic of low polarization-tints, partly due to such of the mica as lies more or less flat in the field, but in which one is led to expect also quartz or felspar, or possibly both. More or less of the component grains of this mosaic show faint dark crosses, due to spherulitic structure, as of chalcedony.

---

[1] In the matter of illumination, I have for a long time given up attempting to work by daylight, which in this climate is usually of too inferior a quality and too capricious for anything but low-power work. After experimenting in various ways I now make use of an ordinary good microscope-lamp burning paraffin. The lamp-chimney is of pale-blue glass, and the bull's-eye condenser used with it is also blued, by cementing to the flat side of it. with Canada-balsam, sufficient thicknesses of pale-blue glass so that the field of light obtained in the microscope appears bright white, like the *best* daylight. The adjustment of the quality of the light can also be controlled by observing the colours in polarized light of several points on a quartz-wedge (or better, on a mica-wedge made as recommended by Mr. Dick) first in good daylight and then in the light of the lamp. The depth of blue glass added to the condenser should be such that the colours are exactly the same in both cases. Then, with a good full flame and using the broad side of it, the light should be so thrown on to the mirror, from the flat side of the condenser, that the mirror is just covered with light. The effect in the microscope is the same as working with an exceptionally fine sky and one is sure that one's work will not be spoilt by a change in the light. Anybody who has once got used to working in this way and to the great advantage of always working with the *same* light will not again forego its advantages, but will, even in the daytime, make exclusive use of artifical light. My own experience also is that work with a good steady *white* light of this sort is less trying to the eyes than anything else.

A proper quantity of powder of this slate having been carefully prepared in the above manner with acid and caustic potash (especial care being taken to wash out the last traces of the potash), was dried at 110° C. and a very careful analysis has been kindly made for me by my friend Mr. George Paterson, of Liverpool, to whom I am much indebted for the great trouble he has taken in making this and the following analyses for me.

Silica	=	69·22	per cent.	
Alumina	=	15·70	,,	
Ferric Oxide	=	5·20	,,	(Includes a good deal of undetermined ferrous oxide,—hence excess in the total.)
Lime	=	1·45	,,	
Magnesia	=	1·80	,,	
Potash	=	4·90	,,	
Soda	=	trace		
Water	=	2·95	,,	
		101·22		

A consideration of this analysis shows at once that a large amount of free silica is present. It is, perhaps, not of much use to calculate the mineral-composition, even approximately, from the above figures, because we do not know the constitution of the sericitic mica, which is probably more complex than normal muscovite, and contains lime, magnesia, and iron.

Assuming, for the sake of argument, that its composition is similar to that of muscovite (Tschermak's formula), and that all the potash of the analysis is in the mica, then the alumina required would be 16·06 per cent. as against 15·70 shown by the analysis. But then there is the garnet to provide for, and we have no safe basis on which to calculate its composition. It is probably a lime-iron-alumina garnet. Also there may be felspar present finely diffused in the mosaic. All that we are able to say with safety is, that after removal of the abundant chlorite from this slate we have remaining a mixture which would correspond, in round numbers, to something like 50 per cent. of sericitic mica and garnets, and 50 per cent. of free silica in the form of quartz with apparently some chalcedony. In some slides the minute quartz-mosaic expands and gets coarser at places. when its nature is more easily made out. Felspar is not usually distinguishable in it. We may look upon it that the original andesitic and other volcanic dust of the rock has decomposed in such manner that the augite and other ferro-magnesian constituents gave rise to chlorite with garnet, while the felspathic part of the mixture was largely altered to mica.

It is pointed out by Tschermak (Mineralogie, third edition, p. 467) that during the alteration of potash-felspar to mica, a large part of the silica is liberated, together with the greater part of the potash in the form of silicate. Rosenbusch also points out the same thing, and shows that soda-lime felspars undergo a similar change, which, however, then involves also a separation of lime as calcite (Microscop. Physiographie der Mineralien, pp. 516, 543).

The silica thus liberated accounts for the finely diffused quartz (and chalcedony) above described, while calcite, also due, doubtless, in part to the same processes in the felspars, abounds in all these rocks. Some of the very fine-grained bands may be seen almost free from it, as is the slate we are just now considering; but it has then been deposited all the more copiously in the alternating coarser bands.

Whether in these cases of mica-formation in plagioclase-felspars the resulting mica is sometimes largely soda-mica (paragonite), or is due only to the potash which is so usually contained in these felspars, does not appear to have been ascertained. It would be very difficult, if not impossible, to get decisive chemical evidence. It seems reasonable to suppose that in some cases, at any rate paragonite will be formed in a manner precisely analogous to the production of muscovite. So far as this Mosedale slate is concerned however, the analysis appears to show that paragonite is not present. All analyses of Lake District andesites show a notable percentage o potash, which there is good reason to suppose is mainly contained in the felspar and glass of the ground-mass, and the ashes and tuffs mainly contain also more or less of rhyolitic, and possibly trachytic fragments.

Garnets are alluded to as present in some of the Lake rocks by Mr. Ward and by Mr. Sorby, but in both cases, as far as I understand it, in a larger form. I do not know that its presence so finely disseminated and in such abundance has been pointed out. Slates like these at Mosedale, full of minute garnets, occur also at many other parts of the district, and it has occurred to me whether some of them might not have good qualities as whet-stones conferred upon them by the presence of this mineral. The celebrated "coticule" of Viel Salm is considered to owe its virtues to the garnets contained in it; these are, however, very much larger than the largest of the grains in the Mosedale slates.

The "base" of the slates is not all garnetiferous. It often occurs, both by itself and in mixture with coarser matter, quite free from garnet-grains, but in other respects exactly the same as just described. An example of this may be taken from the old quarries at the top of Kentmere Valley, a little below the reservoir. Some of the slates here are of the utmost fineness and smoothness and in outward appearance could not be distinguished in any way from some Welsh sedimentary slates.

The microscope shows the same intimate mixture of chlorite, mica, and ultra-fine quartz-mosaic, but free from garnet. A sample prepared as before was analyzed by Mr. Paterson with the following results:—

Silica	=	74·58	per cent.	
Alumina	=	11·22	,,	
Ferric Oxide	=	4·88	,,	(Ferrous oxide not determined.)
Lime	=	1·60	,,	
Magnesia	=	2·00	,,	
Potash	=	2·83	,,	
Soda	=	0·55	,,	
Water	=	2·45	,,	
		100·11		

We see here that silica is in still greater abundance, and that soda has not so fully disappeared, which perhaps partly corresponds to the fact that some few small grains of clastic felspar are still discernible in the specimen from which this analysis was made, the material having been a trifle coarser than the Mosedale specimen, in which no such grains now remain. The soda may also be here partly in the mica, or there may be also regenerated felspar in the mosaic.

The above two occurrences of fine-grained slate were selected partly for the reason that from among many examined they seemed, on microscopic examination, to be the most highly micaceous and most completely altered, and the subsequent analyses bore out this selection. Another instance may be given of a very fine-grained slate (from a quarry at Grasmere), which gives chemical results differing considerably from the former ones. Under the microscope just the same things are seen as in the Mosedale slate. It differs in containing more chlorite and a good deal of finely-disseminated calcite; and it is rather less micaceous. After extraction with acid and potash as before, just the same sort of material remains behind, the garnets being rather larger than at Mosedale.

A sample was prepared, half of which was extracted as before, and the original and extracted portions were taken by Mr. Paterson for determination of silica and alkalies, the following figures being obtained:—

		A. Original.		*B. Extracted.*	
Silica	=	61·75 per cent.		77·40 per cent.	
Potash	=	0·85 ,,	6·34 p.c.	2·40 ,,	7·27 p.c.
Soda	=	5·49 ,,		4·87 ,,	

Looking first at analysis B., we see that a very large amount of soda is present as compared with the Mosedale and Kentmere cases. The potash-percentage is not very different from that at Kentmere.

Comparing A. and B., the most striking fact is that though the removal of the chlorite and calcite has tripled the potash-percentage in the residue, the soda has not only not kept pace with it, but has actually diminished, so that much the greater part of it has been removed by the digestion with moderately strong acid.

As regards the form in which the soda is contained in these samples, it is not possible to make any definite statement, as the microscope does not assist us. There is hardly a trace of clastic felspar to be identified; how much may be present as minute dust still, or as secondary material in the fine mosaic, cannot be ascertained.

The solubility of so large a part of the soda may be explained in two ways. Zeolitic minerals exist in these rocks, and though nothing can be made out microscopically in this instance, there may be a considerable amount of soda-zeolites finely disseminated.

There is another explanation which may not improbably be combined with the above, viz. that this particular band of slate was formed from an ash much more basic than in the case of the Mosedale and Kentmere bands. It may be noted that the most basic rock hitherto observed in the Borrowdale series occurs near Grasmere (GEOL. MAG. Dec. 1891, p. 538), and some of the coarser ashes in the neighbourhood also point to basic rocks. The fine slate now under consideration is traversed by bands of coarser material. One of these, within an inch from where the material for analysis was taken, though obviously originally composed largely of lapilli, is now almost wholly made up of grains of chlorite and calcite, pointing to rocks more basic than the usual andesites as having been largely among the components. The finest dust of such material would contain more labradorite, or other basic felspar, than do the andesites. The removal of much calcite and iron in solution, during decomposition of the augite, etc., of such dust, would cause a relative enrichment as to silica and alkali (A. is richer in alkali than most ashes and other rocks in the district). Finally, alteration of the fine ash may be here less complete than in the cases previously dealt with, and there may still be some labradorite, etc., present, finely divided, and attacked during digestion in acid.

Of the soda which remains in B. some part may be in the mica, and a part—probably the larger part—as felspar. Some of this felspar may be original dust of more acid felspars, but it is more likely that it is in the form of "regenerated" felspar in the mosaic with the quartz and mica. Examination of the coarser ashes and tuffs, as well as andesites. of this district, shows the regeneration of felspar (albite, andesine?) to be most abundant and widespread (see further on), and though the microscope is not able to demonstrate it in the very fine-grained mosaic of this "base" of the slates, it is quite reasonable to suppose that such regeneration has in some cases taken place there also, under the same conditions of chemical change and intense dynamic action.

At any rate, whatever be the correct explanation of the chemical facts as to this particular slate, we see that, taking these rocks as a whole, the processes which have gone on are complex and diverse, and that the microscope is even more than usually in need of chemical aid in attempting to interpret them.[1]

(*To be concluded in our next Number.*)

VI.—THE AGE OF THE HIMALAYAS.

By W. T. BLANFORD, LL.D., F.R.S., etc.

WHEN a case is hopeless, there are two recognized ways of ignoring the fact, and yet of appearing to reply to an adversary. One is the legal device commonly known as 'abusing the plaintiff's attorney,' the other is the equally familiar method of replying to something that the opposite party did not say. The latter has been preferred by my friend Mr. Howorth in his paper on "The Absence of Glacial Phenomena in large parts of Western Asia and Eastern Europe," published in the February Number of the GEOLOGICAL MAGAZINE, pp. 54–64, as the following instances will show.

(1) In the August Number of this MAGAZINE for last year (p. 373), I contended that the salt plains of Central Asia afford no proof of the former occupation by the sea or by extensive lakes of the depressions in which salt now collects. I said, however, that the evidence afforded by similar plains in Persia appeared to me at one time so strong that I was led away by it and mistook them for ancient lake-basins. These remarks of mine, which, as any one may see by referring to them, relate solely to the salt plains, are applied by Mr. Howorth to the observations of Humboldt, Tchihatcheff, Von Cotta and Severtsof on the absence of glacial phenomena in the Urals, Altai Mountains, and Thian Shan range. I thought I had especially guarded myself against being drawn into a discussion about mountains concerning which I know nothing; and I must protest against words of mine relating to one part of the argument, the salt plains, being applied to a distinct subject, the glacial phenomena on mountain ranges. To prevent any mistake, I may add that the circumstance of my declining to discuss any question about these ranges by no means implies that I admit either the accuracy of the views quoted, or of Mr. Howorth's deductions from the quotations.

(2) I pointed out that Mr. Howorth's argument about the Himalayas appeared to be this: that if the Himalayas existed during the

---

[1] It is interesting, in connexion with these fine-grained ash-slates, to refer to the "altered ashes" in the contact-zone of the Shap granite, as described by Harker and Marr. The intimate mixture of chlorite, mica, and quartz gives rise to the much larger mosaic of quartz and biotite. The quartz is converted into much larger individualized grains. The sericitic mica is absorbed into the biotite, as is so usually the case when sedimentary slates are altered by granite-contact. The finely-disseminated garnet (if originally present in the ashes at Shap) is apparently also re-absorbed during these processes, as I have sought for it in vain in many Shap sections.

In the mosaic of these Shap contact-rocks felspar is sometimes seen, sometimes not, which fact rather lends support to some of the inferences I have drawn as to the interpretation of the analytical results.

Glacial epoch, the Himalayan glaciers would have invaded the plains of India, just as the Alpine glaciers reached the plains of Lombardy; and I said that this was precisely equivalent to arguing that the glaciers of the Alps at the present day ought to descend to the sea-level because those of Greenland do so, the difference in latitude between the Himalayas and Alps being about the same as that between the Alps and Greenland. Mr. Howorth says he does not quite understand the reference to latitude; he asks what latitude has to do with the question, and then proceeds to a disquisition about the Urals, Altai Mountains, and Northern Rockies. I decline to complicate the question by dealing with these mountains. Mr. Howorth says it is not latitude that has to do with the question, but an abundant supply of moisture and a sufficiently powerful source of cold. I can only conclude from this that, in Mr. Howorth's opinion, the temperature of the earth's surface does not vary with the latitude, or did not in the Glacial epoch, and that the distance from the Equator has no relation to the "source of cold." I quite admit the importance of an abundant supply of moisture in the production of glaciers, and I believe the reason that no glacial markings are to be seen on some mountains is simply due to want of sufficient snow.

(3) By far the best example of a reply of Mr. Howorth's to something that I did not say is in the case of the Tibetan Rhinoceros. I said (p. 374), "where Yaks can find food, there is no reason why a Rhinoceros should not obtain subsistence." I also pointed out that the remains of *Pantholops*, an antelope now peculiar to high elevations in Tibet, occurred with those of the Tibetan Rhinoceros, and I asked if it were more likely that *Pantholops* formerly inhabited a low level or the Rhinoceros a high one. These two arguments Mr. Howorth says he does not quite follow, and, to show that he does not, he understands me to say, "that because the Wild Ass and the Antelope can live now at great heights, the Rhinoceros could do the same."

This is really a stroke of genius. It is almost a pity that Mr. Howorth, having set up so beautiful a man of straw, should have been tempted by the bad example of his predecessors in the art, into dealing with his creation as it has been customary to deal with men of straw from time immemorial. For in his song of victory over his discomfited puppet, he deals with subjects concerning which his acquaintance is somewhat imperfect. He informs us, for instance, that the Rhinoceros is a tree-feeding and shrub-feeding animal, which is startling, as two of the five species now, or very recently, existing, namely, *R. simus* and *R. unicornis*, live, or lived, chiefly, if not entirely, on grass, and then he adds that "we know the kind of trees which the *Rhinoceros antiquitatis* fed upon," which is perfectly true, but has nothing to do with the food of the Tibetan Rhinoceros, for whatever the latter may have been, it was assuredly not *R. antiquitatis*, nor had it any near affinity to *R. antiquitatis*. A reference to the "Catalogue of Fossil Mammalia in the British Museum" (vol. iii. p. 158) will show that the Tibetan Rhinoceros was closely allied to a species belonging to *Aceratherium,* a small hornless (extinct) group, with well-developed incisors in both jaws. *R. antiquitatis,* as is well known, was a huge two-horned animal without, or almost without, incisors.

Nor is this all. We know that *R. antiquitatis* fed on certain trees (I believe it ate grass also, but this is immaterial), but we also know, not from the examination of teeth belonging to two or three skulls, but from numerous observations on the wild animal, that the nearest living (or recently living) ally of *R. antiquitatis,* the so-called White Rhinoceros of South Africa, *R. simus,* feeds or fed entirely on grass (see, for instance, P.Z.S. 1881, p. 726), so that any inference as to the Tibetan Rhinoceros being a tree- and shrub-feeder, from what is known of the food of *R. antiquitatis,* would be worthless, even if the two species were closely allied, instead of belonging, as they do, to very different sections of the genus.

Again, we are told by Mr. Howorth that the Rhinoceros does not graze on short grass. From the context it may be fairly inferred that the grass of Tibet is regarded as short. Now 'short' is a relative term; various members of the family of grasses vary in length from two or three inches, or even less, to 20 feet at least (without including bamboos). But if by short grass Mr. Howorth understands turf, such, for instance, as is found on most English hills, I can only say that the Tibetan grass, which is described by Kinloch as coarse and wiry, grows in tufts amongst stones, and does not deserve the term. Moreover, as Lydekker has shown (Records Geol. Surv. India, vol. xiv. 1881, p. 183), there is a considerable amount of low bush and other vegetation besides grass on parts of the Tibetan plateau. I believe the whole argument was completely covered by what I urged before, that where a large bovine like the Yak can find subsistence, a Rhinoceros (and especially a Rhinoceros no larger than a Yak) can do the same.

Mr. Howorth also says he does not understand "why the existence of a zoological sub-province in China, which has been established by a chain of observers from Brian Hodgson to Père David, precludes the notion, otherwise so strongly supported, that the Highlands of Eastern Asia are a recent feature in physical geography." Here the fault may have been mine in not explaining my argument more clearly, though in cases where I thought I was thoroughly explicit, Mr. Howorth, I regret to say, finds great difficulty in following my reasoning. The point is one of considerable interest, and I may perhaps be allowed to explain it more fully.

In the first place I must explain that my remarks on the fauna of Tibet do not refer to the zoological sub-province in China, by which of course Mr. Howorth understands the Indo-Chinese sub-region of Wallace, comprising the Himalayas and Southern China. Both Brian Hodgson's and Père David's collections were chiefly composed of specimens belonging to the fauna of this sub-region, which is part of the Oriental or Indian region. But both these collections contained a few gleanings from the true Tibetan fauna which belongs to the Palæarctic region, and contains scarcely any Oriental forms.

Wallace, in his "Geographical Distribution of Animals" (vol. i. p. 216), did not distinguish the Tibetan fauna from the Siberian. Hodgson wrote a paper on the Mammals of Tibet in 1842; but this list is naturally imperfect, whilst some of the species enumerated are not Tibetan. I gave a somewhat fuller but still very imperfect list in 1876. I have drawn up the following list of known Tibetan Mammals from various sources, several additions having been made by Büchner in his description of Przewalski's collections from Northern Tibet. The limits of Tibet, as I understand it, are the Himalayas on the south, the Kuenlun, Altyn Tag and Nan-shan on the north; and the plateau extends from Ladak to Koko-nor inclusive, and probably comprises part of Kansu in China. No part of the plateau, so far as is known, is less than 12,000 feet above the sea; but of course our information about the region is still imperfect.

MAMMALIA OF THE TIBETAN PLATEAU.

INSECTIVORA.

Crocidura aranea.
†_Nectogale elegans._

CARNIVORA.

Felis manul.
F. lynx.
F. uncia.
*_Paradoxurus laniger._
Canis lupus, var. _laniger._
Vulpes alopex, var. _flavescens._
*_V. ferrilatus._
Cyon Deccanensis, var.
Mustela foina, var.
*_Putorius larvatus._
*_P. canigula._
P. alpinus, var. _temon._
P. erminea.
*_Meles leucura._
*_M. albogularis_ ?
†_Æluropus melanoleucus._
Ursus arctos, var. _pruinosus._

RODENTIA.

†_Eupetaurus cinereus._
*_Arctomys Himalayanus._
*_A. robustus._

RODENTIA—_continued._

*_Mus sublimis._
*_Microtus (Arvicola) Blythi._
*_M. limnophilus._
*_M. Strauchi._
*_M. (Eremiomys) Przevalskii._
Siphneus Fontanieri.
*_Lagomys Curzoniæ._
*_L. rutilus._
*_L. erythrotis._
*_L. melanostomus._
*_L. Ladacensis._
*_Lepus oiostolus._
*_L. hypsibius._

UNGULATA.

Equus hemionus, var. _kiang._
*_Bos grunniens._
*_Ovis Hodgsoni._
O. Vignei, var.
*_O. nahura._
Capra Sibirica.
†_Pantholops Hodgsoni._
†_Budorcas taxicolor_ ?
*_Gazella picticaudata._
*_Cervus affinis_ ?
Moschus moschiferus.

In this list * signifies a peculiar species, † a peculiar genus, that is a species or genus not known to exist out of Tibet. It will be seen that out of 46 species in the preceding list three are marked with a note of interrogation. In the case of one of these, _Meles albogularis_, the locality is not I think clearly ascertained, and there is a possibility that neither _Budorcas taxicolor_, nor _Cervus affinis_, is truly Tibetan, though the first, at all events, is probably so. It should also be added that several of the forms, such as _Canis laniger_, _Putorius temon_, _Ursus pruinosus_, _Equus kiang_, here classed as varieties of widespread types, are by many naturalists regarded as peculiar species, and _Bos_ (_Poëphagus_) _grunniens_ and _Gazella_ (_Procapra_) *ıdata* as peculiar genera. But omitting all doubtful forms, king no account of varieties or subgeneric types, it will be that in the preceding list of 43 species, 27 are peculiar, and genera, 4. So far as I am aware there is no other instance world of a continental area of the size of Tibet that contains ally peculiar Mammalian fauna. It should also be remarked far the largest proportion of species ranging beyond Tibet ibited by the Carnivora, which are great wanderers, and that the Ungulates, wide-ranging forms as a rule, only four species nine (omitting *Budorcas* and *Cervus affinis*) are found elsetwo at least of these four being represented in Tibet by well-l varieties. Of the Rodents, 16 in number, only one species is to range into other parts of Asia. The solitary Oriental ı or Indo-Chinese) species in the whole list is *Cyon Deccanensis*, called Wild Dog of India, which, strange to say, does occur Tibet plateau, whilst the Siberian representative of the genus, *us*, is absent. In other respects the affinities of the Tibetan al fauna are distinctly Palæarctic.

ve said that so far as I am aware no other continental area of ne size with an equally distinct fauna is known. For similar les of specific and generic distinction we must look to islands. lifference, for instance, between the Mammalian fauna of ascar and that of Africa is far greater than that between ımmals of the Tibetan plateau and those of other parts of l and Northern Asia; whilst the differences between such islands as Sumatra, Java and Borneo, or between any of them e Malay Peninsula, is much less. On the whole the greatest ity to the Mammalian relations of Tibet is presented by the of Celebes, provided the Australian affinities of a minority Celebean Mammals be neglected.[1]

view is, I believe, generally accepted that the difference fauna of any island from that of the nearest land is due to n of greater or less duration; and if the theory of evolution pted, and it is admitted that the different forms of Mammals, r nearly or distantly related, have a common origin, it is a ıble conclusion that the amount of difference between the inhabiting two neighbouring but separated areas has a distinct ı to the time that has elapsed since the areas were isolated ach other; those tracts in which there is a generic difference been longer separated than those in which the distinction specific.

s it is probable that the separation of Borneo, Sumatra and rom each other and from the Malay Peninsula, is not older 'leistocene or Newer Pliocene, the isolation of Java being of hat earlier date than that of the other two islands. The ion of Celebes from the rest of the Oriental region must be ncient, and in "Island Life" Wallace suggests that it may ck to Miocene times. Bearing in mind that the isolation of

are probably of later introduction than the Mammals with Oriental the Tibetan plateau is far less perfect as regards Mammals than that of any island, and that some of the forms—the Carnivora especially—found in Tibet are probably very recent immigrants, it is a reasonable conclusion that the peculiar fauna of the Tibetan plateau has been distinct from that of neighbouring countries since Middle Tertiary times.

But what has caused the isolation of the Tibetan fauna? Why, in this one continental tract is there a generic and specific differentiation of the Mammalia of which no other example exists? There is only one character in which Tibet is different from other continental areas, its great height. This alone renders the climate of Tibet so different from that of other parts of Central Asia, which are equally cold and barren. It seems a reasonable inference that the elevation of the Tibetan plateau dates back to Middle Tertiary times.

It is of course probable that the elevation was gradual; and although the area may have been sufficiently high at the close of the Miocene period to produce a difference in climatal conditions, the greater part of the upward movement may have been post-Miocene, and a great part post-Pliocene.[1]

I hope I have succeeded in making myself understood. I do not expect Mr. Howorth to concur; in all probability he has no more faith in evolution than he has in subaerial denudation, and will prefer to attribute the origin of genera and species to the same unknown agency as that which he supposes to have produced the river valleys of the Himalayas.

But really arguing with Mr. Howorth is hopeless work. I thought if there was any one point that I had clearly shown it was that the late Mr. J. Campbell's evidence as to the absence of glacial action in the Himalayas was worthless. Mr. Campbell never went near the higher Himalayas, and he himself compared his distant view of the Sikhim mountains from Darjiling to the look-out upon the Alps from the church tower of Novara in Lombardy. This and his other opportunities of seeing the higher Himalayas, might fairly be regarded as similar to those of a Swiss tourist, whose knowledge of the Bernese Oberland is confined to a view of it from the Rigi. Would Mr. Howorth accept the opinions of the Rigi visitor as to the presence or absence of glacial action in the Rhone Valley?

Mr. Howorth quotes two "experienced observers," Mr. Campbell and General MacMahon, whose testimony is decidedly at issue with mine and who have visited "the country" (p. 55). Now "the country" can only be the tracts "high up in the Himalayas" mentioned in the previous paragraph. I can only repeat that Mr. Howorth is in error in supposing that Mr. Campbell visited the higher Himalayas. With regard to General MacMahon's evidence, I regret I did not reply before; but all I can say is this: that I think Mr.

---

[1] In my last contribution to this question in the August Number of this MAGAZINE, there is a mistake, that I must have overlooked in the proof, on p. 373. I wrote: "Surely to say that 'a movement has been distributed over the Tertiary and post-Tertiary period and a great portion is of post-Pliocene date,' is not the same as to say that the whole movement, or even the greater part of the movement, is post-Pleistocene." The last word has been by mistake printed post-Pliocene.

Howorth would have done wisely either to avoid quoting General MacMahon or else to give the whole of his evidence and not merely the few extracts which are in favour of Mr. Howorth's thesis. For although in his "Notes of a Tour through Hangrang and Spiti," General MacMahon remarks on the paucity—not the absence—of old glacial markings, in another paper "On the Geology of Dalhousie in the North-western Himalaya" (Rec. Geol. Sury. India, vol. xv. p. 49), he gives an account of moraines and ice-marks on the outer ranges at an elevation of only 4700 feet above the sea, and thus absolutely contradicts Mr. Campbell on the only point concerning which the latter's evidence was valid, the presence of glacial markings on the lower Himalayan spurs. Why is this important observation ignored? an observation not by a mere visitor like Mr. Campbell, but by an officer who long resided on the spot and had exceptional opportunities for careful observation?

A little consideration will show that General MacMahon's notes on Spiti agree with the observations in other high Himalayan valleys in showing that the glaciers during the Glacial epoch descended considerably below their present level. General MacMahon especially notes that the Spiti valley itself at an elevation of about 11,000 feet appears to have been moulded by ice. Naturally the question that occurs is—What is at present the mean level to which glaciers descend in the Spiti valley? Strange to say, although the ranges that surround the valley rise to 19,000 or 20,000 feet, there are no glaciers at all on the Spiti side except (as General MacMahon tells me) a very small one just inside the Bhabeh Pass. It is clear that in this case the ancient glaciers descended far below the level at which glaciers can now exist. And it is only right to add that 11,000 to 12,000 feet, the lower limit, according to General MacMahon, of the ancient glaciers in the Sutlej valley, is considerably below the level to which any now descend, so far as I am aware, in any part of the Himalaya.

In concluding these remarks, which have extended to an inordinate length, partly because hitherto, when I endeavoured to compress my arguments, I have unfortunately failed to make myself understood, I may briefly point out that, whilst I have accepted battle on Mr. Howorth's ground, and fairly met the arguments he has brought orward, he has never attempted to deal with the data on which the geologists who have devoted most time and study to the Himalayas have been led to the conclusion that these mountains were undergoing elevation throughout a great part of the Tertiary era. The questions of the glacial evidence, and of the Tibetan Rhinoceros, are side issues, and although I believe I have shown that Mr. Howorth is in error in both instances, and only appears to have made out a case because he has left out half the evidence, yet both might be decided in his favour without necessarily involving the recent origin of the Himalayas. Almost any hypothesis may be rendered plausible by gnoring the principal arguments that are opposed to it, and by selecting from the works of various writers a series of extracts hat appear to tell in its favour. If, for instance, any one wishes to demonstrate that the earth is flat, he will, I think, not find it difficult to support his contention by evidence similar in kind and equal in force to that by which Mr. Howorth has attempted to prove "the very recent and rapid elevation of the Himalayas."

VII.—Replies to various Criticisms.

By J. F. Blake, M.A., F.G.S.

THE criticisms which appeared in the January and February Numbers of the Geological Magazine, on certain writings of mine, require some reply. It is obvious that when an author ventures in any way to question or remark upon the results of others, he must expect their opposition to his statements. I have to offer a general apology to all authors on whose writings I have ventured to make critical remarks in the "Annals of British Geology," that I was unable to send them proofs of the articles before publication, as I hope to do in future, as long as the work is continued. In that way misunderstandings would be avoided. However, I must now proceed to business.

1. General MacMahon complains that a passage put in inverted commas is not his. It should not have been *all* put in inverted commas, I admit, yet I cannot see that it involves any misrepresentation of his views. The removal of silica spoken of cannot be thought to refer to the *two molecules* of olivine dealt with, as that would spoil the equation, but, as the statement is said to be thus brought into harmony with Roth's, it must refer to the additional half molecule, or the fifth if we start with four. So far from saying Gen. MacMahon's account must be wrong, I tried to point out how it really agreed with Roth's, though it appeared to differ. To use the General's illustration, if the son had received a *cheque* for one pound, and could only get 16s. cash for it, which he spent, his outing, though the items in his account only amounted to the latter sum, would still cost his father a sovereign. If every four molecules *converted into* serpentine involve the breaking up of a fifth, then it requires five molecules to *produce* two of serpentine. I am sorry that Gen. MacMahon has not availed himself of the chance I offered him, of giving us the calculation about the volume involved.

The question I asked as to why the infiltrating water does not alter the outside of a mineral, on its passage to the centre, is satisfactorily answered, provided, of course, (1) that increase in basicity in a mineral of the same general composition renders alteration easier; (2) that minerals whose centres decay first show a zonal structure, and, if this be applied to olivine, that that mineral should be zoned; (3) that corroding agents in contact with slightly varying material do not act on the several parts in proportion only to the ease of doing so, but leave the more difficult untouched till the other is all consumed. Is all this well known to be true?

There can be no doubt that, as Gen. MacMahon says, water, or at least its chemical elements, finds its way into the heart of minerals; but does it do so as water? and does it occupy intra-molecular spaces? This, however, I have not ventured to discuss, but only to criticize the actual arguments brought forward in this connexion. I wrote "*sic*" after the word atoms partly because it sounded so funny to read of the "atoms *and* molecules of which minerals are composed," which is like saying that a sentence is composed of letters *and* words, and partly because I was not sure whether the phrase was a mere redundancy, or whether it was actually intended to be stated that heat enlarged the distance between the atoms in a molecule. This may be the case for all I know, but I do not think it can be quoted as a generally admitted fact. General MacMahon will thus see that his somewhat cruel inference as to why I wrote "sic" is not corrrct.

My illustration about hydrate of sodium sulphate is more to the point than Gen. MacMahon appears to think—the gist of it is that it gives an example of dehydration by heat in the *presence* and not "in the absence of water." General MacMahon says he was considering capillary flow under heat and *pressure*, but in the paper he really only discusses the action of heat, and the present discussion on the effect of pressure is a new one. In reply to it, however, it may be said, that though, under the circumstances, increase of pressure may be accompanied by increase of head of water, the effect of pressure on the *mineral* or rock would be to close the pores and retard the supposed capillary action, just as a squeezed sponge will not hold so much water as a loose one. On the other hand, it would facilitate a certain kind of chemical change by bringing the molecules more within range, and might thus cause hydration, not mechanically, but chemically; other kinds of chemical change it would retard.

2. Mr. S. S. Buckman complains that statements which are really his are made to appear as mine. I cannot find them. Everything not in square brackets is supposed to originate with the author of the paper. He cannot see that his species are of a "most restricted kind" because he has only made five new species out of 27. True; but the other 22 are already of the most restricted kind. I have not a word to say against, but only admiration for, the *principle* of working out genetic series; but a genetic series is not a zoological genus, but something more restricted; and the reasons relied upon by Mr. Buckman, when given, for considering two forms genetically connected are certainly to me in many cases "apparently arbitrary." Take the case discussed of *Haugia occidentalis*. It is said to be a senile form, and to have lost the knobs characteristic of the *variabilis* group. But the only proof offered that it belongs to the group is the statement (under *H. Eseri*) that this "is very plain from their suture line" which is nowhere either figured or described for *H. occidentalis* that I can find; and though the author subdivides the strata most minutely, this and the knobbed forms occur in the same subdivision. Is not then the assumption that this is a senile form of a knobbed genetic series an arbitrary one?

Next as to *H. Eseri*. Is it possible, indeed probable, that the figures 3, 4, are meant for the true *H. Eseri* of Oppel; but fig. 3 is drawn with a rounded and not an angular or even perpendicular edge to the umbilicus as it should be. *To judge from the figure,* it would be a different form.

As to *G. Aalense.* If specimens with different-sized umbilicus, different character of ribbing, and different shape of inner edge, are all varieties of one species, and no indication given of what is the common feature that binds them all together, something further in the way of "proof" does seem possible.

G. subquadratum versus *G. Sæmanni.* No two specimens of Ammonite are probably identical, but these *seem to me* (and that is all I say) to be so alike, even in the matter of coiling, after measurement, that no sensible differences can be appreciated from the figures.

On the question of the keel on the cast of a hollow-keeled Ammonite I am clearly in the wrong. I was certainly not aware that so well-marked a one could co-exist with a hollow keel above it, till Mr. Buckman was kind enough to send me a specimen in which the fact is indubitable.

3. Mr. Lydekker says that a superficial knowledge of the subject would enable any one to gauge the value of my criticisms. I do not think myself that it requires even a superficial knowledge to appreciate them, merely some common sense. It certainly never struck me that *Orthopleurosaurus* was meant for a simple rectification of *Orthocosta,* in spite of the somewhat superfluous remark that the latter is hybrid. The proper rectification, following the author's guidance of "*polydens*" changed to "*multidens,*" would be *Recticosta.* We are not told whether this is objected to, or whether it and *Orthopleurus* are preoccupied, nor is any reason given why *-saurus* is added on, so that even now no reason is given for the actual result of the change.

4. Dr. Callaway has ordered pistols for two and coffee for one. But he scarcely expects me, I think, to accept his challenge. I have nothing to gain by doing so, if victorious. The fact is, I am so thoroughly convinced of my own power of making a mistake, even when it seems most obvious that I cannot have done so, that I never come to a conclusion of my own, much less propound one for the acceptance of others, till it rests on so many foundations that I feel sure they cannot all be wrong; the advantage of which is that I can afford to give away a few, if contested, without the conclusion being much damaged. I do not by any means give away the observations in question; but if Dr. Callaway likes to take them, it is not worth while to run after him.

NOTICES OF MEMOIRS

I.—Fossil Dragon-Flies.

In the following work—A Synonymic Catalogue of *Neuroptera odonata* or Dragon-flies, by W. F. Kirby, F.L.S., etc., 8vo. Gurney & Jackson, London, 1890—is an Appendix (pages 165–176) enumerating all the known Fossil *Odonata,* with authorities;

synonyms, geological stages, and localities. This useful catalogue comprises—Libellulidæ.—Libellulinæ: 3 genera, namely, Æschnidium (3 species), Libellulium (3 species), Libellula (20 species). Libellulidæ.—Corduliinæ: 1 genus (2 spp.). Æshnidæ.—Gomphinæ, 10 genera; Æshna (3 spp.), Gomphoides (2 spp.), Ictinus (1 sp.), Protolindenia (1 sp.), Heterophlebia (7 spp.), Stenophlebia (5 spp.), Cordulegaster (3 spp.), Cymatophlebia (1 sp.), Uropetala (4 spp.), Petalura (3 spp.). Æschnidæ.—Æschninæ, 2 genera; Anax (1 sp.), Æschna (11 spp.). Agrionidæ.—Agrioninæ, 3 genera; Isophlebia (2 spp.), Tarsophlebia (1 sp.), Euphæa (3 spp.). Agrionidæ.—Cœnagrioninæ, 7 genera; Podagrion (1 sp.), Dysagrion (3 spp.), Cœnagrion (10 spp.), Steropoides (1 sp.). Lithagrion (2 spp.), Agrionidium (1 sp.), Lestes (5 spp.).

Geologically the species appear to be distributed thus:—

Miocene: Œningen, 15; Schossnitz, 3; Auvergne, 1; The Brown Coal, Rott & Sieblos, 9; Amber, East Prussia, 3.
Oligocene: Radoboj, 3; Florissant, 7.
Eocene: Provence, 1; Monte Bolca, 1; Wyoming, 3.
Cretaceous: Queensland, 1.
Purbeck: 7, Dorset and Wilts.
Jurassic: 31, Solenhofen, Eichstädt, Pappenheim.
Lias, Upper: 3, Dumbleton.
Lias, Lower (and Rhætic): 5, Strensham, Binton, Cheltenham, Schambelen.

T. R. J.

II.—THE GEOLOGY AND MINERAL SPRINGS OF PANTELLARIA. By CAV. G. JERVIS, F.G.S. "The Mediterranean Naturalist," Malta, December 1st, 1891, Vol. I. No. 7, pp. 93–96.

PANTELLARIA, the largest of the outlying islands belonging to Sicily, and containing one of the twelve Sicilian volcanoes, lies 53 miles from Sicily, and 34 from the coast of Tunis. It is 8½ miles in length and 4½ in breadth, with an area of 25,423 acres. Its Montagna Grande rises 2742 feet, and it has other mountains of less height. The south and east sides have precipitous cliffs; but at the northern extremity the ground slopes gently downwards to the coast with its little port. The town of Pantellaria has 3167 inhabitants; and 4148 people live in the five country villages or groups of cottages. Volcanic rocks, and rich soil from their decomposition, constitute the country. The volcano itself had numerous prehistoric eruptions, from centre and sides. As a member of the Lipari, Vulcano, and Ischia system, it may not be regarded as quite extinct, especially since earthquake shocks, and a submarine eruption not far from the coast, occurred in October last. It may be noted that an upheaval of the sea-bed for 40 fathoms would convert the Adventure Bank, now about 40 miles from Pantellaria towards Marsala, into an island, 14 miles long, and 3 miles broad, and rising nearly 200 feet above sea-level. Thirty-seven miles N.E. of Pantellaria, and 25 miles from the south coast of Sicily, the Graham Shoal remains where the submarine volcano in 1831 formed the island which has since gradually disappeared. East of Pantellaria, in the direction of Malta, the little island Limosa is also volcanic, thus widening the extent of this volcanic region.

Like Ischia, Pantellaria has thermo-mineral springs, used formerly by the Romans and Arabs; and indeed of the same character as those of Vichy and Ischia; and, if the surroundings were rendered more favourable by the removal of the convict-station to some other Italian island, and if some little capital were then judiciously laid out, these medicinal waters might have much therapeutic and economic importance as a convenient Mediterranean resort. In the eastern part of the island are the Candareddu de lu Bagnu; also the Bagnu or hot lake in an old crater; and the Acqua della Grotta di Gadir. At the S.W. end of the island is the Acqua della Cala Nità, the hottest of all; not far off the Acqua del Porto di Saura Basso; and northwards, about five miles from town, is the Acqua salina di Sataria. There are also fumaroli, or emanations of aqueous vapour. One, termed Bagno secco, is in a cave, forming a Stufa or Sudatorium.

Some sulphur occurs in old fumaroles. The alkaline bicarbonates in the Candareddu de lu Bagnu and the Cala Nità transform the silica of the rock into soluble gelatinous silica, and then deposits it as a dirty-white or grey opal. Obsidian, pozzolana, pumice, and some special minerals also occur in the island. The mineral wealth and springs of Sicily and Pantellaria are described in Mr. Jervis's "Mineral Waters of Southern Italy," and "Subterranean Treasures of Italy."[1] T. R. J.

III.—The Existence of Numerous *Radiolaria* in the Jurassic and the Eocene of the North of France. By L. Cayeux. (Annales de la Société Géologique du Nord, Vol. XIX. 1891, pp. 300-315.)

§ I. M. Cayeux has found *Radiolaria* (1) In some Eocene tuffeaus (tufaceous limestones); (2) In the Oxfordian "gaize" (clay) with *Ammonites Lamberti*. They will be described in detail by-and-bye. 1. The rocks improperly termed "tuffeaux" consist of organic debris with a siliceous cement. The organisms are Sponge spicules, a few Diatomaceæ, and a large number of various spheroidal skeletons of *Radiolaria*, belonging to Häckel's *Monosphærida* and *Disphærida*. *A*. The Landenian Tuffeau at Bouchevesnes has about a sixth of its bulk made up of *Radiolaria*; at Malincourt Tournay, Lille, Angre, and Radinghem they are rare. *B*. The Ypresian Tuffeau of Mont-des-Cats.

These discoveries in the Lower Eocene are important in as much as the *Radiolaria* described by Shrubsole from the London Clay are the only other Eocene forms known, if those described from the jasper of Tuscany be really Jurassic as regarded by Rüst and Häckel.

2. *Radiolaria* have been found in the Oxfordian Clay at Launois, Lalobbe, and La Neuville (Ardennes). Microscopic sections of small hard morsels of this "gaize" show a somewhat similar structure to

---

[1] Geological Mag. 1889, pp. 176–177.

that of the "tuffeaux"; but quartz and other minerals are less abundant, Sponge spicules rarer, and Diatoms are absent, whilst *Radiolaria* make up a third or even a half. The minute sphæroidal objects are less globular and smaller; but, when isolated, prove to be *Radiolaria* of Häckel's *Sphærida* group, a large number belonging to the *Disphærida*. M. Cayeux has not found *Radiolaria* in the Cretaceous "gaizes." Dr. Rüst has discovered quantities in the Jurassic jaspers, flints, cherts, etc., of Hanover, Bavaria, the Tyrol, etc. The Oxfordian clays above mentioned are to be regarded as ranking with Häckel's "mixed Radiolarian rocks"; not being so rich as "the pure Radiolarian rocks" of Nikobar (Oligocene), Barbadoes (Miocene), and the Jura (Jurassic); and therefore deposited at a less depth than 2000 fathoms, to which condition the included quartz sand also has reference.

§ II. The probable origin of the silica in the Gaize and the Tuffeaux. M. Cayeux, previously treating of the microscopic fossils of the tuffeau and gaize, and of the Meule (Millstone) of Bracquegnies, showed that there are Sponges in each of these, that there are Sponges and Radiolarians in the "gaize," and, besides these, numerous Diatoms in the "tuffeau." These organisms naturally secreted silica from the sea-water, and left it when they died. The origin of the flint of the Chalk is here referred to this kind of intervention on the part of Sponges, and the silica of the tuffeaux and gaizes to the above-mentioned siliceous organisms. In these opinions the author finds support in conclusions arrived at by Dr. Hinde and Messrs. Jukes-Browne and Hill. T. R. J.

REVIEWS.

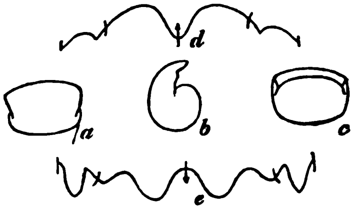
I.—NOTE ON THE DISCOVERY OF CLYMENIA IN NORTH AMERICA.

THE recent discovery of *Clymenia* in the Upper Devonian (*Intumescens*-zone) of Western New York by Mr. John M. Clarke is as unexpected as it is interesting.[1] The *Clymenia* was found in a calcareous concretion in Shurtleff's Gully, Livingston County, New York," not far up in the shales of the Naples Beds," and was accompanied by specimens of *Gephyroceras*, *Tornoceras*,[2] *Bactrites*, sp. nov. (near to *B. carinatus*, Münst.), *Loxonema Noe*, Clarke, *Palæotrochus præcursor*, Clarke, *Platystoma minutissimum*, Clarke, etc. The specimens comprised "about thirty examples of a single species [*Clymenia* (*Cyrtoclymenia*) *Neapolitana*, sp. nov.] in an exceptionally fine condition of preservation, affording the various stages of growth from the protoconch to maturity." The species is remarkably small, the largest mature individual collected having a diameter of only 14 millimetres. The umbilicus is wide, exposing all the volutions, the number of which is 5½ or 6. The whorls are flattened on the sides and periphery, widening towards the dorsal or inner side. It results from this that the section of the body-chamber is subtrapezoidal. The protoconch (Figs. *a*, *b*, *c*) or initial-chamber, which Mr. Clarke had the good fortune to develop, is "broad, transversely ellipsoidal, and has a diameter of 0·9 millimetres." The flattening of the periphery just described, is not apparent until the 5th and 6th whorls are attained. In these the body-chamber is covered with "fine elevated, falciform striæ," which bend sharply forward on either side of the periphery, upon which they form a backwardly directed curve. The ornamentation of the early whorls is very characteristic, and consists of a series of "lamellar, spinous processes" on the margins of the periphery. The dorsal (internal) position of the siphuncle was observed in several instances.

---

[1] See Amer. Journ. Sci. Jan. 1892, vol. xliii. p. 57.

[2] It may be well to explain that the names *Gephyroceras* and *Tornoceras* apply to genera of *Goniatites*, erected by Hyatt out of the old genus *Goniatites*.



Clymenia Neapolitana, Clarke.

a—c, Three views of the initial-chamber (protoconch); *d*, the form of the suture at 2¼ revolutions; *e*, the mature suture. (After J. M. Clarke.)

The form of the suture-line will be understood by referring to the figures (*d*, *e*). The author compares his species with *Clymenia spinosa*, *C. binodosa*, and *C. subarmata*, all of Münster. From the last-named species it differs essentially in the mature suture. Its resemblance to *C. spinosa* is shown in its having similar spinous processes on the sides of the whorls in the young shell, while in its suture-line and flattened periphery it is allied to *C. binodosa*.

The restriction of *Clymenia* to the Upper Devonian of Europe is, so far as the present discovery shows, maintained in America, though it occurs at a comparatively lower horizon in that formation in the New World than it does in the Old. "It may be provisionally suggested," observes Mr. Clarke, "that the fauna of the Naples beds embraces representatives of the whole series of the European Upper Devonian faunas from the base of the Goniatite limestone to the base of the Culm; that it is, therefore, a condensed time-equivalent of a series highly differentiated in the transatlantic Upper Devonian succession."

By this important discovery Mr. Clarke has added to his reputation as a palæontological investigator, and geologists no less than palæontologists will rejoice that the invertebrate fossils of America now, as in past time, find such able and enthusiastic exponents.

A. H. F.

II.—Geological and Natural History Survey of Can. Annual Report (New Series): Vol. IV. 1888–89. (Montr William Foster Brown, & Co., 1890.)

THIS voluminous work consists of ten reports, each of whic separately paginated, and distinguished by a letter of alphabet. Some conception may be formed of the wide exten country covered by the Survey when we read that in April 1 sixteen parties were organised for field exploration, and were tributed as follows:—British Columbia, 3; North West Territor Manitoba, 1; Ontario, 2; Quebec, 4; New Brunswick, 2; N Scotia, 2. The Summary Reports by the Director (Dr. A. R Selwyn, C.M.G., F.R.S.) head the list. These contain brief acco of the Surveys undertaken during the season of 1888–89, statistics relating to the Museum at Ottawa (the head-quarters), details of the various additions made to the collections, in the sh of fossils, recent mammals, birds, reptiles, insects, shells, and pla The first report is by Dr. George M. Dawson, and refers to a por of the West Kootanie district of British Columbia. This survey undertaken with "the special purpose of ascertaining the chara and mode of occurrence and association of the ore-deposits, an estimating their prospective importance." The district is descri as rugged and mountainous, and as comprising the southern porti of the Selkirk and Columbia or Gold Ranges of Mountains. physical features are described in detail, as to its rivers (Koot and Columbia), lakes (Upper and Lower Arrow, and Kootan climate, vegetation, and, finally, its general geological features. geological structure is extremely complicated, and the informat obtained during the survey (which only occupied one month) insufficient for a systematic description of the rocks occurring i Nevertheless some clues were obtained regarding the origin habitus of the ore-deposits—chiefly silver-bearing.

"Speaking generally of the district," writes Dr. Dawson, "I n say that the result of my examination has been to convince that the importance of the mineral discoveries made has not b exaggerated, while their number and the area over which they distributed is such as to guarantee a large and continuous outpu good ore, so soon as adequate means are provided for the trans of the product to market."

The oldest stratified rocks of the district, as seen near the sh of Kootanie Lake, are provisionally referred to the Archæan un the name of the Shushwap Series, and consist of mica-schists gneisses, with which are associated hornblende-schists, and ho blende-gneisses, as well as coarsely crystalline marbles. Overly these rocks (at Hot Springs) is a great thickness of grey and gr schists, and these in turn are followed by limestones and bl argillaceous schists, a mass of granite bounding the whole a distance of two to three miles inland. "In evident relation to change in the country-rock is the circumstance that the ores impr almost uniformly in respect to contents of silver in crossing series of veins in a westward direction from the lake, and ris higher above the lake level." It is believed that the rocks overlying the Shushwap Series are in all probability Palæozoic in age, and may eventually be referred to various systems, including the Carboniferous, and extending downward to the Lower Cambrian.

Dr. Dawson's report is accompanied by a "reconnaissance" map (coloured geologically) on a scale of four miles to the inch, and is also illustrated by two views of Kootanie Lake.

Mr. R. G. McConnell, assistant to Dr. Dawson, gives the results in Report D. (pp. 1 D to 163 D) of an exploration in the Yukon and Mackenzie Basins, North West Territory. The Survey was carried out under Dr. Dawson's direction, and in connection with the Yukon Exploring Expedition. It occupied parts of the seasons of 1887–1888. In a "Geological Summary" the occurrence of Archæan rocks is noted east of the Rocky Mountains, on the Slave River, and at Fort Rae, while unfossiliferous dolomites, limestone, and calcschists, supposed to be of Cambro-Silurian, or later Cambrian age, were met with along the Liard River, west of the Rocky Mountains. Upper Devonian rocks containing many characteristic fossils were observed on the Hay and Mackenzie Rivers, and Triassic rocks and fossils on the Liard River. Cretaceous rocks were recognized east of the foot-hills, containing fossils similar to "Series C." of the Queen Charlotte Islands; among them were *Placenticeras Perezianum*, *Camptonectes*, and *Inoceramus*. Tertiary beds, resting unconformably on the underlying Cretaceous shales and Devonian limestones, were seen at the mouth of Bear-River. Remains of plants, described or determined by Sir William Dawson, were abundant in some of the beds. The age of these Tertiary beds is judged, on stratigraphical, as well as lithological evidence, to be Miocene, though Sir William Dawson refers them, on the plant evidence, to the Laramie. A chapter on "Superficial Deposits and Glacial Action," and a synopsis of the economic minerals of the region, which include Gold, Silver, Copper, Salt, Petroleum, etc., concludes the geological portion of this report; the remainder is taken up with a minute description of the physical features of the routes followed by the surveying party. The report succeeding Mr. McConnell's in the series is on the Exploration of the Glacial Lake Agassiz in Manitoba, by Mr. Warren Upham (pp. 1 E. to 156 E.); but it has already been reviewed in its separate issue in this Magazine (May, 1891, p. 228). Dr. R. W. Ells presents a report (pp. 1 K. to 159 K.) on the Mineral Resources of the Province of Quebec, in which he describes the metals and their ores (Gold, Silver, Copper) and the various minerals used for heating and lighting (Coal, Peat, Petroleum); chemical manufactures (Apatite, Chromic Iron, Manganese), materials used in construction (Marbles, etc.), and the refractory materials, which include Graphite, Asbestos, and Soapstone. Mr. Robert Chalmers reports upon the Surface Geology of Southern New Brunswick (pp. 1 N. to 92 N.), and records the results of careful investigations, in the cleared and settled parts of the country, in regard to glacial striæ, Boulder-clay, stratified deposits, alluvium, the agricultural character of the soil, forests, etc.

The author failed to find any traces of a continental glacier, though he examined the glaciation of the eastern extension of the high pre-Cambrian ridge or plateau bordering the Bay of Fundy with some care. On the contrary, great masses of decayed rock *in situ* encumber the northern and north-western flanks of the ridge, while along the valleys of rivers descending from it northwardly striæ were found clearly indicating northerly ice movements. Till or Boulder-clay was found wherever there were traces of glacier or iceberg action, and in some places where there were none. Mr. G. Christian Hoffmann (pp. 1 R. to 68 R.) reports upon the work carried on in the Laboratory of the Survey, in which he was assisted by Mr. Frank D. Adams,[1] and Mr. R. A. A. Johnston. A report upon the Mining and Mineral Statistics of Canada for the year 1888 is supplied by Mr. H. P. Brumell (pp. 1 S. to 93 S.); and Mr. E. D. Ingall, Mining Engineer to the Survey, presents his "Annual Report" for 1889 upon the same subject (pp. 1 S. to 123 S.). An "Annotated List of the Minerals occurring in Canada" by Mr. Hoffmann (pp. 1 T. to 67 T.), closes this bulky volume, of which the foregoing brief notice can give but a very inadequate idea. We can only express the hope that the work of the Geological Survey of Canada is duly appreciated by those for whose benefit it is undertaken, and that successive Administrations will maintain it in the high state of efficiency it now enjoys. A. H. F.

III.—TENTH ANNUAL REPORT OF THE UNITED STATES GEOLOGICAL SURVEY, 1888–89. By J. W. POWELL, Director. Part I.—Geology. 1890, pp. 774, plates and maps, xcviii.

THE present Report, like those which have preceded it, bears the stamp of the high degree of excellence which the Survey has attained under the direction of Major J. W. Powell, with the assistance of a staff which seems to include nearly all the principal geologists of the United States. The field of investigation comprises the whole of the country; it takes in every formation, from the Pleistocene to the Archæan, and embraces every branch of the science, whether Stratigraphical, Petrographical or Palæontological. To give a list only of the different branches of the work, which, as shown in the Director's Report and in that of the Administrative Chiefs, is being carried out in different parts of the country, would more than occupy our space, and we can here only touch on some points of special interest. One of these is the discovery by Dr. C. A. White in certain counties in Texas of a group of rocks, containing an admixture of Palæozoic and Mesozoic types of fossils belonging to one fauna, which show a conformable passage of the Coal-measures into the Mesozoic series, and thus fills up one of the widest breaks in the geological succession in the United States, viz., that between the Carboniferous and the Jura-Trias. Another series of rocks with similar fossils has also been noticed in Southern Kansas.

---

[1] Mr. Adams has since been appointed Lecturer on Geology at McGill University, Montreal.

In Archæan geology, Prof. Pumpelly has studied the structure of the Green Mountain Range, which consists of a series of closely appressed and overturned folds with a pre-Cambrian crystalline core, and a surface of rocks apparently representing the Silurian, from the Hudson River downwards, and the whole of the Cambrian, as shown in Eastern New York.

Dr. G. H. Williams has been at work on the crystalline rocks of the Piedmont Region, in the Middle Atlantic Slope, and the volcanic and other crystalline rocks about Baltimore. He has made out in the volcanic rocks a sequence of basic, ultra-basic, and acidic eruptions, following each other in accordance with von Richthofen's law.

At the other end of the scale, Prof. N. S. Shaler has been mapping the morasses and superficial deposits of Massachusetts, Rhode Island, and New Hampshire, and he estimates that nearly one-half of the swamp areas in the United States, which by suitable treatment may be made fit for agriculture, are to be attributed to the disturbance of the drainage by the last Glacial Period.

One distinctive feature of this report is the establishment of a division of geological correlation, under the superintendence of Mr. G. K. Gilbert. The specialists in each geological group or system have to prepare essays on the present state of knowledge of North American systems; on the principles of geological correlation and taxonomy; and on the possibility or otherwise of using in all countries the same set of names for stratigraphical divisions smaller than systems, from the American standpoint. Further, as the result of a conference of the members of the Survey, an independent system of nomenclature, of colours and conventional symbols for maps, has been adopted.

Of the papers or monographs accompanying this report, the principal is that of Mr. C. D. Walcott on the Fauna of the Lower Cambrian or Olenellus zone, which has already been reviewed in this Magazine. Another is that on the Morasses, etc., by Mr. N. S. Shaler, and a third is an abstract of a report by the late Prof. R. D. Irving and Prof. Van Hise on the Penokee iron-bearing series of Michigan and Wisconsin. This series of rocks situated on the south and west shores of Lake Superior, has a thickness of about 14,000 feet. It is placed by the authors as a distinct system, named the Algonkian (=Huronian), coming between the Cambrian and Archæan. The lowest member of the iron-bearing series in this region is a cherty limestone in which bands of white chert or quartz are interlaminated with the limestone. The cherty material in some places is 45 feet in thickness, and the silica varies from amorphous to crystalline. One peculiar feature in this chert is the tendency to assume a brecciated form, in which angular fragments up to 2 or 3 inches across are imbedded in chert of a precisely similar character. Sometimes the brecciated portions are wholly included in the cherty zone. Though no organic remains have been met with, either in the limestone or the chert, the authors consider that both kinds of rock are probably of organic origin, and they compare the chert with the beds of the same material which in this and other countries have lately been proved to be derived from organisms.

Above the limestone and chert series is a set of rocks known as quartz slates of a distinctly fragmental texture. The iron-bearing member is next above and consists of slaty and often cherty iron carbonate, ferruginous slates and cherts, and actinolitic and magnetitic slates. The iron-carbonate is sometimes mingled with cherty silica, sometimes the two materials are in solid bands, alternating with each other. In some of the carbonates of the Penokee series there still remains a large percentage of organic matter. The authors further show that the deposits of iron-ore now largely worked are in part due to a concentration of the carbonate of iron which had been widely distributed in the higher strata. They consider that the chert was simultaneously deposited with the iron-carbonate, and that there has probably been an extensive re-arrangement of the silica originally present.

IV.—BULLETIN OF THE UNITED STATES GEOLOGICAL SURVEY. NOS. 62, 65, 67 to 81. 8vo. Washington, 1890–91.

THE latest numbers of this publication which have reached us show that the United States Survey, under the able direction of the Hon. J. W. Powell, still maintains its high standard of excellence, and is as much a pattern to our authorities as ever, save in the delay that takes place in their issue. The wide extent of ground covered by these mostly bulky numbers is certainly remarkable. Nothing comes amiss, provided it bears in any way on the work of the Survey. Thus we have a report on the astronomical work of 1889 and 1890 (No. 70). Two numbers (72 and 76) are lists of altitudes; the latter being a second edition of the "Dictionary of Altitudes in the United States," and not a bad gazetteer at a pinch. The "Viscosity of Solids" (73), and the "Report of work done in the division of Chemistry and Physics" (78), together with "Earthquakes in California in 1889, by J. E. Keeler" (68), which is a continuation of the lists given by Prof. E. S. Holden up to 1888 in a previous number, bring the list of Bulletins that are not strictly geological to an end.

Turning next to the stratigraphical memoirs we light first on G. H. Williams (62), "The greenstone schist areas of the Menominee and Marquette Regions of Michigan," which is "a contribution to the subject of Dynamic Metamorphism in Eruptive Rocks;" the greenstones, and certain intimately associated acid rocks. are alone dealt with, no attention being paid to the quartzite, dolomites, or shales of the younger Huronian. The conclusion arrived at is that the greenstones of these areas are eruptive rocks, the foliated character of which is a secondary feature.

"The relations of the Traps of the Newark System in the New Jersey region" form the subject of No. 67. Mr. N. H. Darton shows that in their genetic relations these traps belong to two classes; first the extrusive sheets contemporaneous with the inclosing strata, and typified by the great lava flows constituting the Watchung Mountains; and, second, intrusive sheets and dikes of subsequent age, of which the celebrated Palisade trap on the shore of the Hudson River is an *example.*

Mr. J. S. Diller describes "A late Volcanic eruption in Northern California" (79). The cinder cone, 10 m. N.E. of Lassen Peak, marks the scene of one of the very latest volcanic eruptions in the United States, and is composed wholly of ejecta inclosing a perfect crater 240 feet deep. Two epochs of eruption are noted as having taken place, the first about 100 years before the American revolution, the second at a much later date, but more than 50 years ago. The lava, which is a basalt, is especially noteworthy on account of the phenocrystic quartz which it contains.

The "Stratigraphy of the Bituminous Coal-field of Pennsylvania, Ohio, and West Virginia" (65), is dealt with by Mr. J. C. White in a very exhaustive manner, and illustrated by no less than 152 woodcuts of sections in 212 pp. of text. "Correlation Papers" form the subject of two Nos. (80 and 81), "Devonian and Carboniferous by H. S. Williams," and "Cambrian by C. D. Walcott." Both these are bulky papers, and as they summarize the results obtained by all previous observers. their extreme value to all students of Palæozoic geology cannot be overrated.

In Bulletin No. 77 is presented a summary of the evidence that may be accepted as indicating the Permian age of a certain series of strata in Western Texas, which have been referred sometimes to the Trias and sometimes to the Permian. The discovery in these beds is moreover recorded of certain types of invertebrate fossils which are usually regarded as indicative of Mesozoic age, commingled with a considerable number of Carboniferous types, including well-known Coal-measure species.

Two important compilations relating to fossil Insects come from the pen of Mr. H. S. Scudder:—No. 69 "A classed and annotated Bibliography of fossil Insects" pp. 101, and No. 71 "Index to the known fossil Insects of the world, including Myriapods and Arachnids," pp. 744. What, we wonder, would the authorities of H. M. Stationery Office say were our Survey to suggest the publication of a series of useful bibliographies such as these? The first is an extension to date of the one published in 1882 by the Harvard University as No. 13 of their "Bibliographical Contributions," when it only covered half the number of pages it now takes up. Some of the increased space is of course due to the repetition of titles entailed by the adoption of the classified form in the later edition; but still more to the careful manner in which references bearing in any way on the subject have been looked up and included.

The "Bibliography" is supplemented by the "Index," which is a work no palæontologist, even if it be not his special subject, can well afford to be without; and is exactly what its title describes. The only improvement which suggests itself is that it would have been well to add when possible where the type specimen is now to be seen.

"The Minerals of North Carolina by F. A. Genth" (74) is essentially a new edition of the report published by the Geological Survey of North Carolina in 1881. In the present memoir many new analyses will be found; whilst the "Synopsis of Minerals and Mineral Localities, by Counties," with which the work terminates, will be of *especial* value to the field geologist and the collector of minerals.

In Bulletin No. 75 Mr. N. H. Darton gives a "Record of North American Geology from 1887 to 1889 inclusive." He has previously published one for 1886, which appeared in the same series in 1887. For terseness and the clear way in which the contents are set out, so that the eye of the searcher is not wearied in its endeavours to find the particular paper wanted, we recommend this production to the attention of any who may be disposed to attempt the revival of the ill-starred and more ambitious "British" prototype now years behind time.

V.—The South Italian Volcanoes. F. Furcheim. Naples.

THIS work is one of the results of the excursion of the Geologists' Association to Southern Italy in 1889. The account of the excursion is written by Dr. Johnston-Lavis, who acted as principal director. On September 18th the party embarked at Messina, on a small steamer which had been chartered for a week's cruise amongst the Lipari Islands. In the portion of the report dealing with this part of the excursion much interesting geological information is given, and the exact state of the active vents of Vulcano and Stromboli is described. On returning to Sicily the party proceeded to examine the phenomena of Etna, under the able guidance of Prof. O. Silvestri, of Catania. The celebrated Val di Bove was visited from Acireale, and the central crater from Catania.

On October 1st the party assembled at Naples, and the second part of the excursion was commenced. A fortnight was most profitably spent in this classic region, and the usual objects of interest were visited. The great extinct crater of Roccamonfina was examined on the way to Rome, where the excursion was brought to a successful termination on Oct 28th. Visitors desirous of studying the volcanic phenomena of Southern Italy will find, in this report, valuable information as to the best way of employing their time.

The account of the excursion forms only a small portion of the volume. Of the 335 pages, 239 are devoted to an exhaustive bibliography of the district, which has been compiled by Madame and Dr. Lavis. There are also papers on special subjects by Messrs. Platania, Lavis, Sambon, and Zesi. Sixteen plates complete the volume. Fifteen of these are excellent reproductions of photographs, and three which illustrate successive stages of an explosion in the crater of Vulcano are extremely interesting. They convey a vivid impression of the actual nature of the phenomenon.

The Geologists' Association and Dr. Lavis are to be congratulated on having so successfully carried out a somewhat ambitious programme. They were received with great cordiality by many Italian geologists, and on several occasions experienced great kindness and hospitality at the hands of local authorities.

Now that the slight inconveniences necessarily attendant on such an excursion are forgotten, the members who took part in it must look back with unalloyed pleasure to the time so profitably spent in a district full of interest, both from a geological and from a historical point of view.

REPORTS AND PROCEEDINGS.

◆

Geological Society of London.

I.—Annual General Meeting.—February 19th, 1892.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1891. In the former the Council again congratulated the Fellows on the continued prosperity of the Society, and the perfectly satisfactory condition of its finances.

The number of Fellows elected during the year was 63; of these 43 qualified before the end of 1891, together with 19 previously elected Fellows, thus making a total accession of 62 Fellows during the year 1891. As, however, from this number a deduction of 50 must be made for losses by death, resignation, and removal, and for new Fellows compounding, the actual increase in the number of Contributing Fellows amounts to 12. The total number of Fellows, Foreign Members, and Foreign Correspondents at the close of 1891 was 1418.

The Balance-sheet for the year 1891 showed receipts to the amount of £2845 9*s*. 8*d*., and an expenditure of £2476 5*s*. 7*d*. Moreover, the sum of £516 2*s*. 3*d*. was expended in the purchase of stock, and the balance in favour of the Society at December 31st, 1891, amounted to £286 19*s*. 4*d*.

The Council's Report also referred to the severe losses sustained by the Society during the year in the deaths of several distinguished Fellows, to the death of the late House-Steward, to the editing of No. 185 of the Quarterly Journal by Prof. T. Rupert Jones, and in conclusion announced the awards of the various Medals and proceeds of Donation-Funds in the gift of the Society.

The Report of the Library and Museum Committee enumerated the additions made during the past year to the Society's Library, announced the completion of about 40 previously imperfect sets of serials, and referred to the registration of type specimens in the Museum, a task which has been confided to a specialist, Mr. C. Davies Sherborn.

In handing the Wollaston Medal, awarded to Baron Ferdinand von Richthofen, to Mr. W. Topley, F.R.S., for transmission to the recipient, the President addressed him as follows:—

Mr. Topley,—To Baron Ferdinand von Richthofen the Council of the Geological Society has awarded this year the Wollaston Medal in recognition of the great merit of the researches carried on by him over a large part of the Old World and of the New. From the outset of his career he has been distinguished by a rare combination of the power of minute patient observation, with the faculty of broad, and often brilliant, generalization. It is this union of mental gifts which has placed him high among the leaders of science of his time, and which gives such a charm and value to his writings.

Beginning his early investigations among the eruptive rocks of his native country, he was gradually led to undertake a detailed investigation of the geology of that interesting region in the South Tyrol around Predazzo and St. Cassian. The elaborate monograph of this tract, which he published in 1860, was a remarkable achievement for so young a man, and gave ample promise of his future distinction. Soon after its publication he had the good fortune to be attached to a naval n sent out to the East by the Prussian Government to arrange commercial rith China, Japan, and Siam. He was thus afforded opportunities of turning at his power of rapid observation, of enlarging his geological experience, editating upon those problems to the solution of which he might devote his e are all familiar with the brilliant series of papers and works which has from the labours of the twelve years spent by him abroad.

ig the Pacific he came in contact with Professor J. D. Whitney, who was lucting the Geological Survey of California. The young and eager German ɔed to settle for a time on the Pacific border of the American Continent, devoted himself to the study of the marvellous volcanic phenomena of that Among the contributions made by him to the geology of the United States, :kable generalizations as to the order of succession of the volcanic rocks, and e of 'massive eruptions' have attracted special attention.

he had seen of China had convinced him that an investigation of its geology ove of the utmost interest and value. Accordingly, in the summer of 1868, f turning homewards, he returned to that country, and spent somewhere ree years in a series of journeys through the vast Celestial Empire. The rolumes and splendid atlas which contain his account of China form one of t important contributions ever made to geological literature. In every here is some luminous remark or suggestive inference that lights up the le array of facts with which the pages are crowded. The description of ese Loess and the manner in which the author works out his explanation uzzling formation are a model of geological description.

geologist, a scientific traveller, an exponent of facts, and a generalizer from heir connecting cause, Baron von Richthofen stands in the forefront of ice of our day, and in awarding him the Wollaston Medal this Society does much honour as it seeks to confer on him. When you, Mr. Topley, transmit al to him and express to him our appreciation of his labours, will you also him our personal regard and our hope that he may long be able to continue which has rendered his name so illustrious.

ʼOPLEY, in reply, said:—Mr. President,—I am desired by Baron von en to express his extreme regret that important duties detain him in Berlin, er it impossible for him to be present here to day.

quests me to offer to this Society his warmest thanks for the honour now l upon him, and for placing his name in the list of distinguished geologists this Medal has been awarded.

etter which I have just received Baron von Richthofen says:—"If I were ly present I would not fail to remark that I am deeply impressed by the sness how unfavourably the humble work I have been able to accomplish with the honour now conferred upon it; and that it will be my endeavour r myself more worthy of it by never ceasing to work in the interests of il and, what is so nearly related to it, geographical science, my line of being indeed chiefly in that field where both these branches of science meet. ish geologists have had the largest share in the geological exploration of ntinents than Europe. It has been my lot, too, to do a chief part of my oad. This common interest has, among others, contributed to connect me with my fellow-workers in science in your country. It is a sincere gratification have this tie strengthened by being put under the obligation of gratitude this illustrious Society in which the names of British geologists are l."

eeling of gratification with which Baron von Richthofen will receive this will, I am sure, be shared by the geologists in Germany and Austria. No ld in higher honour by them, both for personal worth and scientific attain- han Baron von Richthofen, and to no one would they more gladly see al awarded.

President then presented the Murchison Medal to Prof. A. en, M.A., F.R.S., addressing him as follows:—

sor Green,—In awarding to you the Murchison Medal, the Council desires its sense of the importance of the contributions which you have made to ledge of English geology, more particularly in the Coalfield of Yorkshire, ch your name will ever be honourably associated. It might not be appro- ere I to allow myself to dwell on the special value of your geological labours. I will only say that they long ago placed you among the ablest field-geologists of this country. But besides the work done by you in the field, and expressed on maps and sections, we owe a further debt to you for the clear, terse, and interesting descriptions which you have given of your researches. It is always pleasant as well as instructive to read one of your writings, and this eminent faculty of exposition you have turned to valuable account in your admirable "Manual of Geology." There is to myself a peculiar pleasure in being the channel through which this Award of the Council comes to you, for I can look on an unbroken friendship with you extending over some thirty years. In handing to you the Medal founded by Murchison, I am reminded of your early intercourse in the Geological Survey under that great leader, when we discussed together the questions to which we have each since devoted ourselves. And I am sure I fulfil the desire of every Fellow of this Society when I express the hope that, in your high position at Oxford and in the original research which you will doubtless still carry on, you may continue for many years that career of distinction which we gladly recognize to-day.

Prof. GREEN, in reply, said:—Mr. President,—Under any circumstances it would be most gratifying to receive from the Geological Society a recognition of my attempts to enlarge the boundaries of our favourite science. But I hold myself specially fortunate on this occasion on two grounds. A Medal that bears the name of the great chief under whom we both served is specially welcome; and a further charm is added when I feel that I am receiving this award from one to whom I have been bound in close friendship for a period of more than thirty years. If anything could strengthen the link that binds us together, it would be the receipt of the Murchison Medal at your hands. I thank most cordially the Society and yourself for the honour you have done me.

In presenting the Lyell Medal to Mr. G. H. Morton, F.G.S., the President addressed him as follows:—

Mr. Morton,—The Lyell Medal has been adjudged by the Council to you in recognition of your long and meritorious services to geology in the work which you have done around Liverpool. To you we are largely indebted for the extent of our knowledge of the Triassic and other strata of that district. Your full and accurate account of the glacial phenomena of your neighbourhood forms an especially important part of your labours. In handing you this Medal, with the sincere good wishes of the Council and of the Society, I may add that, had he been alive, no one would have taken a keener interest in your work or rejoiced more heartily at its due recognition than the illustrious founder of this Medal, Charles Lyell.

Mr. MORTON, in reply, said:—Mr. President,—I fear that I shall fail, by any words at my command, to adequately express how much I appreciate the great honour conferred on me by the Award of the Lyell Medal. This kind recognition by the Council of any original work that I may have done is most gratifying, for it is the greatest honour that can be bestowed on a geologist.

The Medal has been awarded to me before I am too advanced in years to hope to do more work, and it will stimulate me to renewed exertion. The pleasure I now feel is increased at receiving the Medal from your hand, Sir, not only as President of the Geological Society, but as the Director-General of the Geological Survey. I thank you for the complimentary manner in which you have referred to my work in the Triassic and other strata around Liverpool.

The President then handed the Balance of the proceeds of the Wollaston Fund, awarded to Mr. Orville A. Derby, F.G.S., to Mr. H. Bauerman, F.G.S., for transmission to the recipient, addressing him as follows:—

Mr. Bauerman,—I have the pleasure of handing to you the Balance of the proceeds of the Wollaston Fund for transmission to Mr. O. A. Derby, to whom the Council has adjudged this Award in recognition of the value of his various communications on the Geology and Palæontology of Brazil. Some of these writings have far more than a local interest. I would especially refer to those in which Mr. Derby gives the results of his petrographical researches on the nepheline-bearing rocks, on the distribution of the sources of the rarer minerals, and on the ore-deposits of the Jacapiranga district. In transmitting this Award to him, will you convey the best wishes of the Council and the Society for his continued success in scientific investigation.

Mr. Bauerman, in reply, said:—Mr. President,—I have been asked, by telegram from Mr. Derby, to represent him, as the interval since the Award was announced has not been sufficient to allow of an acknowledgment by letter. I thank you heartily for the recognition of the excellent work done by Mr. Derby in a country whose geological structure is almost unknown, and I consider that in addition to the honour conferred on the recipient. the Award is of value as likely to encourage the local government in carrying on the systematic investigation of the province in the manner that they have so worthily begun.

In presenting the Balance of the proceeds of the Murchison Geological Fund to Mr. Beeby Thompson, F.G.S., the President addressed him as follows:—

Mr. Beeby Thompson,—The Balance of the proceeds of the Murchison Fund has been adjudged by the Council to you as a mark of its high appreciation of the insight, endurance, and enthusiasm with which you have prosecuted your laborious investigation of the Upper and Middle Lias of Northamptonshire. Your minute tracing of the successive zones of these formations admirably shows how the Maps of the Geological Survey may be made to serve as the basis for more detailed and exhaustive work, such as can only be undertaken by a permanent resident in a district. We hope that this Award may encourage you to persevere by showing how cordially you possess the sympathies of this Society.

Mr. Beeby Thompson, in reply, said:—Mr. President,—I feel greatly the honour that has been conferred upon me by the present Award. I am a comparatively young geologist, and commenced the study of the science some twelve years ago in connexion with the Northamptonshire Natural History Society. My highest ambition at first was to give a connected *résumé* of all that had been published on the local geology; but I soon found deficiencies in the record, and these I have since done my best to supply. It is now one of the greatest pleasures of my life to go out into the field and interrogate the rocks; and although we frequently come to violent blows, I hope we shall ever remain the best of friends.

I thank you, Sir, for the kind and encouraging words with which you have accompanied this presentation.

The President then presented one-half of the Balance of the proceeds of the Lyell Geological Fund to Mr. J. W. Gregory, B.Sc., F.G.S., addressing him as follows:—

Mr. Gregory,—One moiety of the Balance of the proceeds of the Lyell Fund has been assigned by the Council to you as a token of its warm appreciation of your researches and as an encouragement to you to continue them. You have shown yourself to be an accomplished palæontologist and an able petrographer; and we trust that in both capacities you may live amply to fulfil the promise which you have given of a brilliant career in the future.

Mr. Gregory, in reply, said:—Mr. President,—The Fund which the Council has so kindly awarded me helps me to realize more than usual the responsibility of holding an appointment at the Natural History Museum, for I feel that it to the opportunities afforded by its collections and libraries, and by the generous assistance and encouragement of the more experienced members of the staff, that the little that I have been able to do is entirely owing. You, Sir, have kindly referred to the fact that I have occasionally wandered from the work of descriptive palæontology; I can only offer as an excuse for thus presuming to intrude into the other branch of geological work, the desire occasionally to exchange the air of the museum for that of the field, as well as the wish for the training acquired in pursuing the more precise method of research.

This Award will encourage me to try to continue in the path of its founder in regarding fossils not merely as the cells of a phylogenetic tree, but as the witnesses from whose evidence we must learn the physical conditions and faunistic migrations of the successive periods of the past.

In presenting the other half of the Balance of the proceeds of the Lyell Geological Fund to Mr. Edwin A. Walford, F.G.S., the President addressed him as follows:—

Mr. Walford,—The Council has awarded you the other moiety of the Lyell Fund in recognition of the great merit of your studies among the Lias and Lower Oolites and your contributions to our knowledge of the *Trigoniæ* and *Polyzoa* of the Jurassic rocks. We hope that you will accept this Award as an aid and stimulant to further research, and that we may have the pleasure and profit of continuing to receive the results of your labours.

Mr. WALFORD, in reply, said:—Mr. President,—I thank you for this recognition of such work as I have done. My stratigraphical labours have consisted principally in filling in the details of the broad outlines so well laid down by the officers of the Geological Survey. In palæontology my work among the Mollusca and Bryozoa has been done in the few intervals of leisure snatched from a busy business life. I wish that I had been able to accomplish more, for what I have done is but evidence of what I would wish to do.

The President then handed the proceeds of the Barlow-Jameson Fund, awarded to Prof. C. Mayer-Eymar of Zürich, to Dr. W. T. Blanford, F.R.S., addressing him as follows:—

Mr. Blanford,—In asking you to be so good as to transmit to Prof. Mayer-Eymar a donation from the Barlow-Jameson Fund, awarded to him by the Council, I hope that you will convey to him an expression of the interest we take in the work he is now carrying on so vigorously in Egypt, and of our desire to aid him in it. His previous training in the palæontology of the Cretaceous and Tertiary rocks of Switzerland, France, and Italy eminently qualified him for the task to which he is now devoting himself, and in which we sincerely wish him success.

Dr. BLANFORD, in reply, said:—Mr. President,—I am very pleased to undertake the duty of transmitting the Award from the Barlow-Jameson Fund to Professor Charles Mayer-Eymar. The money will be devoted to one of the most important objects for which these funds were originally founded—the payment of the travelling expenses of a geologist who is engaged in investigating the structure of a distant country.

Professor Mayer-Eymar, in a letter from Cairo written on the 4th of the present month, asks me to convey his thanks to the Society, expresses his warm acknowledgment of the assistance to his work that the present Award will give, and promises, as evidence of his gratitude, to send in the course of next month, for the information of the Society, an account of his three principal stratigraphical discoveries in Egypt.

The PRESIDENT then said:—Before passing from the subject of the Awards, I should like to refer very briefly to the remarkable and interesting coincidence that this Anniversary day of our Society is also the centenary of one of the great geologists who founded our Medals and Funds. Exactly one hundred years ago (viz. on February 19th, 1792) Roderick Impey Murchison was born. Twenty years have passed away since he was removed from our midst; and at this distance of time we can better estimate the value of his work and its influence on the progress of our science. I do not purpose, on the present occasion, to attempt such a critical estimate. I am sure, however, that I express not my own feeling only, but that of every Fellow of the Society, when I say that though we have been able to correct some of his observations, and discard some of his deductions, the solid work which he accomplished, more especially in the establishment of his Silurian system, stands on a basis which seems even stronger and broader now than when he laid it more than half a century ago. His name has become a household word in Geology, and will go down to future ages as that of one of the great pioneers of the science.

To those who knew him personally and learnt to appreciate the frank, generous, and sympathetic nature that underlay the somewhat formal bearing of the old soldier, this day brings many pleasing memories. That the recollection of his personal worth remains yet fresh without as well as within the pale of our Society has been vividly brought to my knowledge by an incident as unwonted as it is gratifying. Within these few days an old friend of Murchison, who desires to remain unknown, has come to me with the wish to be allowed to offer here a tribute to his memory at this Anniversary of the Geological Society and centenary of his birth. As a mark of sincere admiration for the man as well as the geologist, and with the view of helping to encourage the cultivation of the spirit in which he laboured, I have been asked to select two geologists, by preference Scotsmen, who are disciples of Murchison, or who are carrying on the kind of research to which he devoted himself. To each of these workers the generous donor asks to be allowed to give a framed portrait of Murchison together with a sum of £50. The conditions of the gift circumscribed my choice, but I feel confident that I shall carry the Society with me when I say that there are pre-eminently two Scottish geologists who have worthily followed in Murchison's footsteps, but with no slavish regard for the opinions of their master, who are continuing and extending his work, and who by their constant association alike in the field and in descriptive writing deserve to share in this tribute to the memory of their former chief. I need hardly say that I allude to Mr. B. N. Peach and Mr. John Horne.

The President then presented an envelope containing a cheque for £50 to Mr. B. N. Peach, and requested him to convey a similar packet to Mr. J. Horne.

Mr. Peach, in reply, said:—Mr. President,—On behalf of my colleague, Mr. Horne, and myself I beg to thank you for your kindness in considering that we have carried on the work of our old chief, Sir Roderick Murchison, in the true spirit, and I beg to request that you will convey our thanks to the unknown donor of this munificent gift.

The President then proceeded to read his Anniversary Address, in which he first gave Obituary Notices of several Fellows, Foreign Members, and Foreign Correspondents deceased since the last Annual Meeting, including Sir Andrew Ramsay (President in 1862–63), Prof. P. Martin Duncan (President in 1876–77), the Duke of Devonshire (elected in 1829), Mr. R. B. Grantham (elected in 1833), Prof. J. Leidy (elected Foreign Member in 1866), Prof. Ferdinand von Roemer (elected Foreign Member in 1859), Baron Achille de Zigno (elected Foreign Correspondent in 1886), the Earl of Northesk, Mr. Frederic Drew, Mr. J. Thornhill Harrison, Sir J. Hawkshaw, Mr. Thos. Roberts, Mr. C. S. Wilkinson, Mr. Kinsey Dover, and Mr. Collett Homersham.

The other portion of the Address was devoted to a continuation of the subject treated of last year, and dealt with the history of volcanic action in this country from the close of the Silurian period up to Older Tertiary time. The remarkable volcanic outbursts that took place in the great lakes of the Lower Old Red Sandstone were first described. From different vents over Central Scotland, piles of lava and tuff, much thicker than the height of Vesuvius, were accumulated, and their remains now form the most conspicuous hill-ranges of that district. It was shown how the subterranean activity gradually lessened and died out, with only a slight revival in the far north during the time of the Upper Old Red Sandstone, and how it broke out again with great vigour at the beginning of the Carboniferous period. Sir Archibald pointed out that the Carboniferous volcanoes belong to two distinct types and two separate epochs of eruption. The earlier series produced vast submarine lava-sheets, the remains of which now rise as broad terraced plateaux over parts of the Lowlands of Scotland. The later series manifested itself chiefly in the formation of numerous cones of ashes which were dotted over the lagoons and shallow seas. After a long quiescence, volcanic action once more reappeared in the Permian period, and numerous small vents were opened in Fife and Ayrshire and far to the South in Devonshire. With these eruptions the long record of Palæozoic volcanic activity closed. No trace has yet been discovered of any volcanic rocks intercalated among the Secondary formations of this country, so that the whole of the vast interval of the Mesozoic period was a prolonged time of quiescence. At last, when the soft clays and sands of the Lower Tertiary deposits of the South-east of England began to be laid down, a stupendous series of fissures was opened across the greater part of Scotland, the North of England, and the North of Ireland. Into these fissures lava rose, forming a notable system of parallel dykes. Along the great hollow from Antrim northwards, between the Outer Hebrides and the mainland of Scotland, the lava flowed out at the surface and formed the well-known basaltic plateaux of that region.

The address concluded with a summary of the more important facts in British volcanic history bearing on the investigation of the nature of volcanic action. Among these the President laid special stress on the evidence for volcanic periods, during each of which there was a gradual change of the internal magma from a basic to an acid condition, and he pointed out how this cycle had been repeated again and again even within the same limited area of eruption. In conclusion, he dwelt on the segregation of minerals in large eruptive masses and indicated the importance of this fact in the investigation, not only the constitution and changes of the volcanic magma, but also of the ancient gneisses where what appear to be original structures have not yet been effaced.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*Council*: Prof. J. F. Blake, M.A.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; James W. Davis, Esq., F.L.S., F.S.A.; R. Etheridge, Esq., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; Prof. C. Le Neve Foster, D.Sc., B.A.; Sir A. Geikie, D.Sc., LL.D., F.R.S.; Alfred Harker, Esq., M.A.; H. Hicks, Esq., M.D., F.R.S.; G. J. Hinde, Esq., Ph.D.; W. H. Hudleston, Esq., M.A., F.R.S.; Prof. T. McKenny Hughes, M.A., F.R.S.; J. W. Hulke, Esq., F.R.S.; Prof. J. W. Judd, F.R.S.; J. E. Marr, Esq., M.A., F.R.S.; H. W. Monckton, Esq.; Clement Reid, Esq., F.L.S.; J. J. H. Teall, Esq., M.A., F.R.S.; W. Topley, Esq., F.R.S.; Prof. T. Wiltshire, M.A., F.L.S.; Rev. H. H. Winwood, M.A.; H. Woodward, Esq., LL.D., F.R.S.; H. B. Woodward, Esq.

OFFICERS.—*President*: W. H. Hudleston, Esq., M.A.. F.R.S. *Vice-Presidents*; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; L. Fletcher, Esq.; M.A., F.R.S.: G. J. Hinde, Esq., Ph.D.; Prof. J. W. Judd, F.R.S. *Secretaries*: H. Hicks, Esq., M.D., F.R.S.; J. E. Marr, Esq., M.A., F.R.S. *Foreign Secretary*: J. W. Hulke, Esq., F.R.S. *Treasurer*: Prof. T. Wiltshire, M.A., F.L.S.

The thanks of the Fellows were unanimously voted to the retiring Members of Council: Dr. W. T. Blanford, Dr. J. Evans, James Carter, Esq., J. C. Hawkshaw, Esq., and F. W. Rudler, Esq.

II.—February 24, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "The Raised Beaches, and 'Head,' or Rubble-Drift, of the South of England; their Relation to the Valley-Drifts and to the Glacial Period; and on a late Post-Glacial Submergence.—Part II." By Joseph Prestwich, D.C.L., F.R.S., F.G.S. (For Part I. see p. 136.)

The ossiferous deposits of the Caves of Gower are shown to be contemporaneous with the raised sand-dunes between the beaches and the 'head,' and reasons are given for supposing that the elevation of land which preceded their formation need not necessarily have been greater than 120 feet. The mammalian fauna of these caves is the last fauna of the Glacial or post-Glacial period, and the 'head' or Rubble-drift marks the closing chapter of Glacial times.

Evidence is given for considering that the 'Rubble-drift' has a wide inland range, and that to it are to be referred the 'Head' of De la Beche, the Subaerial Détritus of Godwin-Austen, the Angular flint drift of Murchison, and in part the 'trail' of Fisher and the 'warp' of Trimmer, as well as other deposits described by the author. The accumulation is widespread over the South of England, and occurs in the Thames Valley, on the Cotteswold Hills, and on the flanks of the Malverns. The stream-tin détritus of Cornwall and the ossiferous breccia filling fissures (which must be distinguished from the ossiferous deposits of the true caves) are held to be representatives of the 'Rubble-drift,' which is of a variable character.

The author discusses the views of previous writers on the origin of the accumulations which he classes together as 'Rubble-drift,' and points out objections to the various views. He considers that they were formed on upheaval after a period of submergence which took place slowly and tolerably uniformly: and that the absence of marine remains and sedimentation shows the submergence to have been short. This submergence cannot have been less than 1000 feet below present sea-level, and was shortly brought to a termination by a series of intermittent uplifts, of which the 'head' affords a measure, sufficiently rapid to produce currents radiating from the higher parts of the country, causing the spread of the surface-détritus from various local centres of higher ground. The remains of the land animals killed during the submergence were swept with this débris into the hollows and fissures on the surface, and finally over the old cliffs to the sea- and valley-levels. Simultaneously with this elevation occurred a marked change of climate, and the temperature approached that of the present day. The formation of the 'head' was followed in immediate succession by the accumulation of recent alluvial deposits; so that the Glacial times came, geologically speaking, to within a measurable distance of our own times, the transition being short and almost abrupt.

In this paper only the area in which the evidence is most complete is described. The author has, however, corroborative evidence of submergence on the other side of the Channel.

2. "The Pleistocene Deposits of the Sussex Coast, and their Equivalents in other Districts." By Clement Reid, Esq., F.L.S., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

The gales of last autumn and early winter exposed sections such as had not before been visible in the Selsey Peninsula. Numerous large erratic blocks were discovered, sunk in pits in the Bracklesham Beds. These erratics included characteristic rocks from the Isle of Wight. The gravel with erratics is older, not newer as is commonly stated, than the Selsey 'mud-deposit' with southern mollusca. Numerous re-deposited erratics are found in the mud-deposit, which is divisible into two stages, a lower, purely marine, and an upper, or *Scrobicularia*-mud, with acorns and estuarine shells.

At West Wittering a fluviatile deposit, with erratics at its base and stony loam above, is apparently closely allied to the mud-deposit of Selsey; it yields numerous plants, land and freshwater mollusca, and mammalian bones, of which lists are given.

The strata between the brickearth (= Coombe Rock) and the gravel with large erratics yield southern plants and animals, and seem to have been laid down during a mild or interglacial episode. A similar succession is found in the Thames Valley and in various parts of our eastern counties.

III.—March 9, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "The New Railway from Grays Thurrock to Romford: Sections between Upminster and Romford." By T. V. Holmes, Esq., F.G.S.

In the Hornchurch cutting of the new railway, Boulder-clay, of which about 15 feet is seen, rests upon the London-clay near the 100-feet contour-line, and is overlain by 10 to 12 feet of sand and gravel. The author gives reasons for inferring that this sand and gravel belong to the oldest terraces of the Thames Valley gravel occurring in this district, and states that it demonstrates the truth of Mr. Whitaker's conclusion that the Thames Valley deposits are (locally) post-Glacial, or newer than the local Boulder-clay.

2. "The Drift Beds of the North Wales and Mid-Wales Coast." By T. Mellard Reade, Esq., C.E., F.G.S.

This paper is a continuation of papers by the author on the Drift Beds of the N.W. of England and North Wales. The author first treats of the Moel Tryfaen and other Caernarvonshire drifts; he describes the drifts of the coast and coastal plain, connecting his observations with those of the Moel Tryfaen drifts. An important feature of the investigation is the numerous mechanical analyses of the various clays, sands, and gravels. In all the samples but one, a large proportion of extremely rounded and polished quartz-grains have been found, which the author maintains to be true erratics, and a certain sign of marine action. He shows that the Moel Tryfaen marine sands are in part overlain by typical Till, composed almost wholly of local rocks with a small percentage of clay, whereas the sands and gravels are full of erratics including rocks from Scotland and the Lake District, numerous flints, Carboniferous Limestone, and crystalline schists. Throughout the drifts of the coastal plain he has found a greater or less proportion of granite erratics, as well as, in many cases, minute rolled shell-fragments. He maintains that these drifts are the result of two opposing forces, one radiating from Snowdonia, and the other acting from the sea to the southwards, and their characteristics change as the one or the other force preponderated.

The other divisions of the paper are taken up with a description of the Merionethshire drift and that of Mid-Wales, numerous sections being given. Attention is called to a remarkable glaciation of the rocks at Barmouth.

In a concluding part, giving inferences and suggestions, the author discusses the land-ice and submergence hypotheses, and concludes that his observations distinctly strengthen the grounds for believing in a submergence of the land to an extent of not less than 1400 feet.

An Appendix contains details of nineteen mechanical analyses of tills, sands, and gravels, and a bibliography of papers, observations, and theories of the high-level drifts of Moel Tryfaen.

CORRESPONDENCE.

READE'S THEORY OF MOUNTAIN BUILDING.

Sir,—Mr. Jukes-Browne seems to holds peculiar, not to say exacting, views of the way scientific controversy should be conducted. Having replied to Mr. Davison's criticisms on a fundamental principle, without a rejoinder from him, though nearly a year has since elapsed, I am now invited to go on answering him until some unnamed but "good physicists" are satisfied. I need hardly say that this is a labour I must decline. At the same time, I am ready to meet fairly any good physicists who are prepared to speak in their own names.

T. Mellard Reade.

March 9th, 1892.

ON A FAULT WITHOUT A THROW.

Sir,—The north-western part of the Wirral—the district forming the western horn of Cheshire—is very extensively faulted. The prevailing direction of the faults is north and south, but at places east and west faults are met with. These abut against the north and south faults and are generally terminated by them.

A remarkable characteristic of many of these east and west faults is that although they possess slickensided faces and there is evidence of great movements, there is little or no throw.

A very good example is now exposed near Caldy Grange Grammar School, West Kirby. There is a fine flank exposure of a north and south fault just behind the school. It was described by Mr. O. W. Jeffs in 1887 (Proc. Liverpool Geol. Soc. vol. v. p. 247). He mentioned three east and west faults which terminated against the main fault. Since that time another east and west fault has been exposed and was described by Messrs. Beasley and Lomas before the Liverpool Geological Society in February, 1892. This fault has been traced westwards from the main fault for about a third of a mile, and in one part forms a ridge of fault-rock beautifully slickensided about 6 feet wide and rising like a wall above the surrounding Upper Bunter to a height of 6 to 8 feet.

A transverse section is seen in a little cutting west of the Waterworks, and the beds are continued across the fault without the slightest displacement.

Similar east and west faults have been noticed at Storeton and other places, but, so far as I can ascertain, no satisfactory theory has been advanced to explain their peculiarities.

In the Caldy Grange fault the Keuper has been faulted down against the Bunter. It does not follow that the Keuper would move

at the same rate or at the same time along the whole distance of the north and south fault. If we grant differential motion, the matter is explained. The Keuper might slip to a certain point and fracture there, then the other portion falling would slickenside the face, and a throw equal to that of the main fault might leave no residual throw.

J. Lomas, Assoc. N.SS.

OBITUARY.

HENRY NORTON, F.G.S.

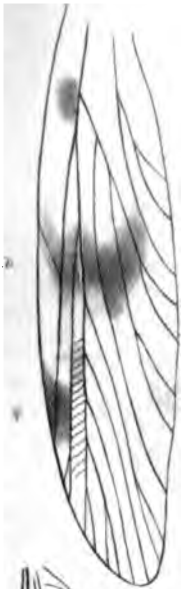
By the death of Henry Norton, of Norwich, we have to record the loss of an enthusiastic student of Norfolk geology, and one of the most learned men of the present century. He was the son of William Norton, Esq., of Old Buckenham, and in his youth was articled to Messrs. Mitchell & Clarke of Wymondham, and afterwards set up practice as a solicitor in Surrey Street, Norwich. Possessed of ample means, he relinquished his profession to devote himself to travelling in the East and throughout Europe. Once, no doubt because of the eccentricity of his conduct, he was apprehended in Vienna as a spy. For many years Mr. Norton devoted himself to the study of Sanskrit, Syriac, Chinese, and other Eastern languages, in which he became so proficient that he was able to read the works of Eastern philosophers and savants in their own tongue. He was also a good Scandinavian and German scholar. Of late years he applied himself a great deal to the study of modern science and philosophy, and more especially to the geology of Norfolk.

He joined the Norwich Geological Society when it was first established in 1864, and became a Fellow of the Geological Society of London in 1875.

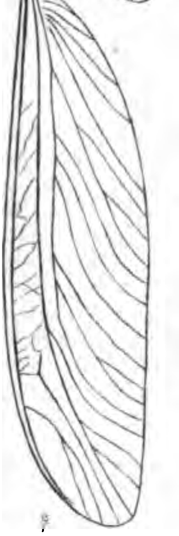
He examined in great detail the sections at Pakefield and Kessingland, and read before the Norwich Society a paper in 1876 (published in the 'Norfolk Chronicle' for May 6). A subsequent communication on the 'Forest Bed of East Norfolk' was issued separately (reprinted from the 'Norwich Mercury' of May 5, 1877); and in this paper he boldly and acutely discussed the evidence that had been published on the subject of stumps of trees being rooted *in situ* in the Cromer Forest Bed. He showed that the published evidence was inconclusive. In 1877 Mr. Norton contributed some notes on species of *Hydrobia* from the Freshwater Beds of Runton and Mundesley (Proc. Norwich Geol. Soc. vol. i. p. 16). In 1879 he read a paper embodying great research on the Atlantis Island, coming to the conclusion that it was in reality the continent of Africa (Proc. N.G.S. vol. i. pp. 75, 80). In 1880 he communicated to the same society (*Ibid.* p. 110) notes on the Palæontology of the Ancients (Greeks and Romans); and also an explanation of the word "Paramoudra" (*Ibid*, p. 132).

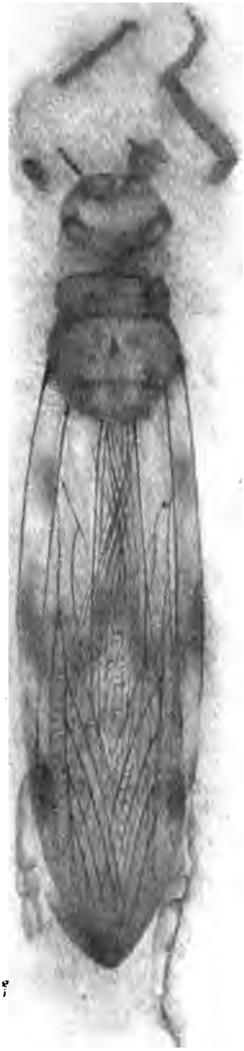
He died in February last, in his 80th year. [Some further particulars of his life were given in the "Eastern Daily Press" of February 24.]

1b



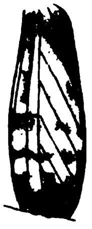
3



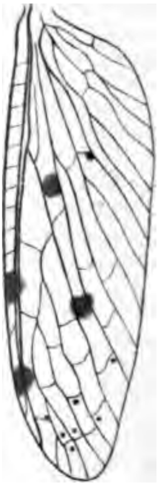


1a

4



2



M Woodward del et lith.

West, Newman imp.

1 Palæotermes Ellisii H. Woodw.
Lower Lias Barrow-on-Soar, &c.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IX.

No. V.—MAY, 1892.

ORIGINAL ARTICLES.

I.—On a Neuropterous Insect from the Lower Lias, Barrow-on-Soar, Leicestershire.

By Henry Woodward, LL.D., F.R.S., F.G.S., of the British Museum (Natural History).

(PLATE V.)

SO much attention has been bestowed of late years on fossil organic remains from rocks of all ages, that it must appear urprising to find so little notice has been directed to the Insect-emains from the British Secondary rocks.

It is now nearly fifty years since that veteran geologist, the Rev. P. B. Brodie, M.A., F.G.S., published his modest little 8vo. volume ntitled "A History of the Fossil Insects in the Secondary Rocks of England"[1] which is still the only separate work of the kind extant. Numerous Insect-remains have, it is true, been described by Prof. J. O. Westwood, Mr. H. E. Strickland, Prof. J. F. Blake, Mr. A. G. Butler, and Mr. S. H. Scudder, from English rocks of Secondary age; and Mr. Herbert Goss has given an excellent summary of our knowledge of the Mesozoic Insects in the Proceedings of the Geologists' Association (1879).

Although fossil insects are rarely well-preserved in our Secondary rocks, yet it cannot be doubted that they were extremely abundant during this period, their remains having been obtained from the Wealden beds of Hastings, Tunbridge, and Maidstone; the Purbeck beds of Durl'ston Bay, of Swanage, and Ridgway, Dorset, have also long been known to yield such organisms, many of them having been figured and described by Brodie and Westwood; whilst the "Insect-limestone" in the Purbeck strata of the Vale of Wardour in Wiltshire, was formerly the happy hunting ground which furnished the materials for Brodie's History of Fossil Insects. Traces of Insects have likewise been obtained from the Kimmeridge Clay, the Oxford Clay, Forest Marble, Great Oolite, Stonesfield Slate, and lastly from the Lias and Rhætics.

Mr. Herbert Goss, F.G.S.,[2] in his excellent summary of the Insect Fauna of the Secondary Period, writes as follows:—

"The Lias and Rhætic formations are the oldest rocks of this period in which fossil insects have been detected in England. In some of the minor divisions insect-remains have been discovered in such abundance that the beds containing them have, as in the 'Purbecks,' been called 'Insect-Limestone.' Fossil insects have been found, chiefly in the lower division of this formation, in Gloucestershire,[1] Worcestershire, Warwickshire, Somersetshire, Dorsetshire, and on the borders of Monmouthshire; a few have also been found in Yorkshire.[2] They are generally in a much more fragmentary condition than those from the 'Purbecks,' and are less common than in the latter formation.

---

[1] London, 8vo. pp. xviii. and 130, with 11 plates, 1845.

[2] See "The Insect Fauna of the Secondary or Mesozoic Period, and the British and Foreign Formations of that Period in which Insect-remains have been detected," by Herbert Goss, F.L.S., F.G.S., Proc. Geologists' Association, 1879, vol. vi. pp. 116-150.

"Mr. Brodie states that he first discovered these interesting fossils in the immediate neighbourhood of Gloucester,[3] and he adds, that some of the beds of limestone in the lowest division of the Lias, in the Vale of Gloucester, abound in insects; and that beautiful specimens, chiefly elytra and wings, have also been found in the Upper Lias at Dumbleton and Alderton.

"At Dumbleton, which is N.E. of Cheltenham, Mr. Brodie obtained from the Upper Lias shales one nearly perfect *Neuropterous* insect, of which Prof. Westwood says[4]: 'It possesses an arrangement of the wing-veins differing from that of any English species, and also from any foreign species known to me, but it comes nearest to the small *Libellulæ* forming the genus *Diplax.*'

"In the Upper and Middle portions of the Lower Lias, which are extensively developed in the neighbourhood of Gloucester and Cheltenham, traces of insects are said to be exceedingly scarce; but at Wainlode Cliff, on the banks of the Severn, near Gloucester, the Insect Limestone has produced remains of several genera of *Coleoptera.* In the Insect-Limestone to the south-west of Combe Hill, not far from the last-mentioned locality, Mr. Brodie obtained a great number and variety of insect-remains, consisting chiefly of the elytra of *Coleoptera,* and a few imperfect but large wings of *Libellulidæ.*

"At Apperley, near Wainlode Cliff, remains of insects have been found in plenty, many small slabs, three or four inches square, exhibiting several elytra and wings, and a few small Beetles.

"From the Insect-Limestone, near the village of Hasfield, Gloucester, many elytra of *Coleoptera* have been obtained. The same formation, in the neighbourhood of Forthampton, near Tewkesbury, has also furnished fossil insects, belonging to the same families as those found in the localities before mentioned.

---

[1] In a note at p. 378 of the Quart. Journ. Geol. Soc. vol. x. 1854, Prof. Westwood states that "A rich collection of fossil insects, from the Lias of Gloucestershire, etc., has been made by Mr. W. R. Binfield, to whom also the Museum of the Geological Society is indebted for a suite of insects from the Lias of Lyme Regis."

[2] The Rev. J. F. Blake has described and figured two fragments of insects from the Yorkshire Lias. One specimen consists of an elytron of a beetle, named by Mr. Blake *Buprestites bractoides*, and the other specimen consists of two wings of a *Neuropterous* insect, apparently belonging to some species allied to *Chauliodes*, which Mr. Blake has named *Chauliodites minor*. See "Yorkshire Lias," by Ralph Tate and J. F. Blake, London, 1876, p. 426, pl. xvi. figs. 5 and 6.

[3] See Brodie's "Fossil Insects," pp. 51–103, and the Quart. Journ. Geol. Soc. vol. iv. 1846, pp. 14–16.

[4] See Quart. Journ. Geol. Soc. vol. v. 1849, pp. 31–35.

"At Strensham, about nine miles from Evesham, insects have been obtained from a bed of Insect-Limestone at the bottom of a large quarry. Amongst them was found part of the abdomen of a gigantic species of *Libellula*, which Mr. Brodie named *Libellula Hopei*. In the neighbourhood of Evesham the Insect-Limestone has produced numerous remains of insects, the wings and elytra of many of which are said to be beautifully preserved. In the lower division of the Lias, in this neighbourhood, Mr. H. E. Strickland[1] discovered small elytra of *Coleoptera* and portions of the wings of *Libellulidæ*.

"From one quarry near Bidford, Warwickshire, Mr. Brodie obtained a small species of the family *Gryllidæ*, which he named *Gryllus Bucklandi* in honour of Professor Buckland.

"In some of the quarries in this neighbourhood (Bidford) the wings of *Libellulidæ* were obtained, particularly at a place called the 'Nook,' where a beautiful specimen was found, which has been described and figured by Mr. Strickland.[2]

"Mr. E. T. Higgins obtained from the Lower Lias or the Rhætics, in the southern parts of Gloucestershire and the adjoining county of Somerset, in the neighbourhood of Bristol, numerous remains of insects. From Aust, near Bristol, and from Sudbury on the Monmouthshire side of the Severn, about three miles from Chepstow, the Insect-Limestone and the 'Landscape-Stone' have afforded a quantity of remains. In some slabs the insects were found imbedded together in masses. In one slab, Mr. Higgins is stated to have detected as many as 30 small Beetles.

"From the frequency of such delicate creatures as insects in the 'Landscape-Stone,' and in another band of Limestone, only a few feet higher, some of which are said to be beautifully preserved, and could not have been long subject to the action of the waves, it is supposed by Mr. Brodie, that this part of the Lias may have been formed in an estuary, which received the waters of some neighbouring coasts, and which brought down the remains of insects and plants.

"*Coleoptera* appear to have been abundant in the Lias, for out of some 300 specimens, or parts of specimens of insects, obtained from this formation, examined by Professor Westwood, more than one-third were referred by him to this order, and included representatives of the *Buprestidæ*, *Elateridæ*, *Curculionidæ*, *Chrysomelidæ*, *Carabidæ*, *Telephoridæ*, etc. 'Most of the species appear to have been very minute, never equalling in size,' observes Mr. Westwood, 'those from the Stonesfield Slate.' The other orders represented in this formation are the *Orthoptera*, the *Neuroptera*, the *Hemiptera*, and (possibly) the *Diptera*?

"The remains of *Orthoptera* include *Gryllidæ* and *Blattidæ*; the *Hemiptera* include *Cicada* and *Cinneæ*, and the *Neuroptera*, *Libellula*, *Agrion*, *Orthophlebia*, *Hemerobius*, *Æschna*, *Chauliodes* and *Ephemera*. Among these various families and genera we have omnivorous, herbaceous, and predaceous species. Many of the families and genera found in the Lias are common both to it and the Purbecks.

---

[1] Quart. Journ. Geol. Soc. 1846, vol. iv. pp. 14–16.

[2] See Mag. Nat. Hist. vol. iv. 1840, pp. 301–303, and woodcuts (New Series).

"Although, as a rule, the remains of insects from this formation are very imperfect and fragmentary, the detached wings of many *Neuropterous* insects are preserved in the greatest perfection, and have the nervures of the wings beautifully defined. The size of the insects, judging from the remains, appears to have been usually small and indicative of a temperate climate.

"It may be observed that nearly all the fossil-insects from this formation have, with the exception of a few specimens from the Upper division, been obtained from the *lowest*[1] division of the Lias, or from the Rhætic series, between the Lias and the Trias. Remains of insects from the Lias and Rhætics are very numerous, but the majority of them are in such a fragmentary condition that it has been impossible, even for those who have devoted special attention to the subject, to make out the species to which they belong. About 56 species, however, have been determined, which are distributed amongst five orders as follows, viz.:—*Coleoptera*, 29 species; *Neuroptera*, 12; *Orthoptera*, 7; *Hemiptera*, 6; *Diptera*? 2 (supposed).

"No traces of *Lepidoptera* or *Hymenoptera* have been met with, and the remains which have been referred to the *Diptera* are extremely doubtful."

For permission to describe and figure the very fine impression of a Lias Insect, which forms the subject of Plate V. Fig. 1, I am indebted to the kindness of Montagu Browne, Esq., F.G.S., Curator of the Town Museum, Leicester, who obtained it from the Lower Lias (*Planorbis*-zone), Barrow-on-Soar, Leicestershire, in 1889, when spending his vacation there. The insect is, so far as I am aware, unique of its kind as a fossil, and is preserved in almost equal clearness, as an impression and counterpart, upon two very close-grained slabs of Lower Lias Limestone, from which the well-known hydraulic cement is so largely manufactured. The insect itself is 54 millimetres in length, the fore-legs extending 12 mm. beyond and in front of the head, which is 6 mm. long and 8½ mm. broad. The three divisions of the thorax measure 9 mm. long by 8½ in breadth. The wings, which are neatly folded together, as in repose, are nearly four times as long as they are wide. In addition to two fore-legs already mentioned, one mandible, part of an antenna, the eyes, and the two hind-legs, are more or less perfectly preserved. The wings are clouded with spots of colour such as one frequently sees in these transparent membranous organs in many living *Neuroptera*; such colour-markings have also been figured by Scudder in *Megathentomum pustulatum* from the Coal-measures of Mazon Creek, Illinois, and in his *Brodia priscotincta* from the same horizon, Tipton, Staffordshire.

The tibia and 5-jointed tarsus of the two fore-legs can be very well seen preserved on the slab; the legs are somewhat stouter than in many modern Neuroptera, and the tibia appears to have been slightly serrated or spined, along the inner margin.

---

[1] Mr. Goss mentions that he had received from the late Mr. Charles Moore, of Bath, a large collection of fossil insects from the *Upper* Lias of Ilminster. This collection included *Coleoptera*, *Neuroptera*, *Orthoptera*, etc.

The head is rounded and of moderate size, with a slight indentation, in front, marking the median line. The mandible, which is serrated, can be seen on the right side, and a portion of the left antenna, with its small bead-like joints, is preserved. The eyes are prominent, but moderate in size. The pronotum is not long and cylindrical as in *Chauliodes*, but is of nearly equal length with the mesonotum and metanotum, but the mesonotum is broadest and is angular in outline. The abdomen is concealed beneath the wings, and its proportions cannot consequently be given.

The wings, in their closed position, measure 42 mm. in length, by 12 mm. in breadth, but being folded upon one another, it is a matter of considerable difficulty to trace the nervures belonging to each of the separate wings. To begin with the anterior border. There is an entire absence of the ladder-like cross-veins which unite the costa with the costal vein in the wings of so many Neuropterous insects; but, apparently, there is a trace of such ladder-like cross-veins to be faintly seen near the distal end of the wings, and *within* their lateral margins, which may possibly belong to the *under*, or hind-wings. With regard to its absence in the upper, or front-wings, it may be explained either (*a*) as not existing; (*b*) as not having been preserved; or (*c*) that the costal margin was folded down out of sight, when the insect was at rest.

(*a*) I do not know of an instance of a Neuropterous insect in which this well-marked marginal line of cross-veins uniting the costal border with the costal-vein, is present in the hind-wings[1] and absent in the front-wings; (*b*) yet it seems unlikely, if it existed, that no trace should have been left along the costal margin in either wing; but (*c*) in a specimen of *Chauliodes Japonicus* (McL.), with the wings closed (which, by the kindness of Mr. Charles O. Waterhouse, I have been enabled to examine, together with numerous other insects, in the Zoological Department), the costal margin of the front wings cannot be seen, being folded down out of sight on each side. I have not seen the living insect; but if this is its normal position when at rest, then it may be that the costal border of the wings of this Lias insect are also concealed in a similar manner beneath the rest of the wing. I do not, however, feel confidence in urging this hypothesis.

After carefully studying the wings and comparing the relative position of the subcostal, the principal, subnodal, median, and subsector veins in recent Neuropterous insects, with the fossil form, I find the points of comparison with *Chauliodes* less satisfactory than I had at first anticipated, and that both in the narrow and elongated form of the wing, as well as its more simple neuration and the absence of the ladder-like cross-veins on the costal margin, there is a greater resemblance to the Termitidæ (sub-order Pseudoneuroptera).

The very distinct evidence of symmetrically-arranged colour-markings and spots on the wings must not, however, be lost sight of, for they closely resemble those observable in many species of Neuroptera (*Chauliodes, Neuromus* and *Palpares*), and they do not appear to characterize the wings of *Termites*, which are uniform in colour. Nevertheless, the late Prof. Oswald Heer, in his "Urwelt der Schweiz" (Zurich, 1865) pp. 85–86, taf. vii., has noticed the wing of a fossil insect from the Lias of Schambelen, Switzerland, with an extremely similar venation to our specimen, and,—it is also very interesting to notice,—*with colour-markings* preserved upon its surface. This wing he names *Calotermes maculatus*. He writes as follows:—"At Schambelen six species of *Termites* have been discovered. They agree with the existing species in the general arrangement of the veins of their wings, but differ from them in many other respects; so that they must be regarded as forming peculiar extinct genera, of which I distinguish two. In one of these (*Clathrotermes signatus*, Heer), pl. vii. fig. 8, the costal area of the wing is divided by delicate transverse nervures, into a series of quadrangular cells, and the wings are spotted with black; in the other (*Calotermes*) these transverse nervures are wanting, but the wings are spotted with black in one species (*C. maculatus*, Heer, pl. vii. fig. 7) and Pl. V. Fig. 4, or they have a dark costal area (as in *C. plagiatus*, Heer, pl. vii. fig. 6). These dark spots and bands *are peculiar to the Termites of the Lias*; for all the living species have colourless wings. The Liassic species, like those of the present day, differ much in size; the smallest (*C. troglodytes*, Heer) has wings only 3¼ lines long; in the largest (*C. obtectus*, Heer), they attain a length of 9 lines" (English translation by W. S. Dallas, London, 1876).

---

[1] As this single line of ladder-like cross-veinlets occurs *within* the wing, it may not after all belong to the margin of the lower or hind-wing, but form part of the cross-veinlets of the front wing itself (as in *Clathrotermes signatus*, Heer).

The new *Termite* from Barrow-on-Soar is relatively so very much larger than any of the remains from the Lias of Switzerland, described and figured by Heer, that it cannot be referred to the same genus, yet it evidently belongs to this peculiar group with spotted wings. Therefore, although I am anxious to avoid the needless multiplication of generic names, I venture to refer our Lias Insect to a new genus, *Palæotermes*, very near to Heer's *Calotermes*, with the distinctive specific name of *Ellisii*, by desire of Mr. Browne, in recognition of his indebtedness to Messrs. Ellis, the owners of the Lias Limestone pits at Barrow-on-Soar, who have, for many years, given him special facilities in the prosecution of his researches.

EXPLANATION OF PLATE V.

Fig. 1*a*. *Palæotermes Ellisii*, H. Woodw., sp. nov. (enlarged twice nat. size); from the Lower Lias (*Planorbis*-zone), Barrow-on-Soar,[1] Leicestershire. One-half is preserved in the British Museum (N. H.), and the other in the Leicester Museum.

Fig. 1*b*. Plan of wing of same, drawn separately, to show probable arrangement of the nervures of the wing. × 2 times.

Fig. 2. Detached wing of *Chauliodes Japonicus*, McL. × 2 times (*ad nat.*).

Fig. 3. Detached wing of *Termes angustatus*. × 2 times (*ad nat.*).

Fig. 4. Detached wing of *Calotermes maculatus*, Heer, from the Lias of Schambelen, Switzerland (copied from Heer's "Urwelt der Schweiz.").

---

[1] The counterpart of this very beautiful Lias Insect has been kindly presented to the British Museum (Natural History) by Montagu Browne, Esq., F.G.S., who has placed the other half in the Leicester Museum.

II.—THE LAMPROPHYRES OF THE NORTH OF ENGLAND.

By Alfred Harker, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

THE north-country lamprophyres occur usually as dykes of no great magnitude, sometimes as sills, more rarely as small bosses or laccolites. They are scattered over an area extending from Teesdale to Furness, from Bassenthwaite to Ingleton. A circle thus defined has a diameter of about fifty miles, and embraces all the known occurrences, though others may exist beyond these limits concealed by post-Silurian strata. In the centre of the circle is the Shap granite, and the probable genetic connexion between the lamprophyres and this granitic intrusion has already been urged by Mr. Marr and the present writer. The chief grounds for such an opinion are as follows:—

(i.) The arrangement of the intrusions, as just noticed, and the radial grouping of the dykes in the central part of the area about the granite.

(ii.) The common age of the intrusions, so far as can be fixed; both granite and lamprophyres being post-Silurian but pre-Carboniferous, and both being connected with the same crust-movements.

(iii.) Certain general chemical relations, to be noticed below; to which may be added some special chemical characters, such as the notable quantity of manganese in the granite and in most of the dykes analysed.

(iv.) The special mineralogical resemblance of many of the dykes to the Shap granite, shown by the occurrence in them of characteristic minerals such as sphene (rarely found in the lamprophyres of other districts), and especially of the well-known porphyritic felspars of the granite. Some of these points are brought out more strongly by comparing the lamprophyres with the dark basic patches so common in the granite.

(v.) The arrangement of the different varieties of lamprophyres, the more basic and characteristic ones occurring especially in the outer parts of the area, the more acid varieties and those having most in common with the granite chiefly in the central tract.[1]

(vi.) The close association with the lamprophyres of acid intrusions of types more normal for apophyses of granites, and the existence of transitional varieties between these acid rocks and the lamprophyres.

Many of the individual rocks have been described by different writers,[2] and it will be sufficient here to recall some of the more significant characters which they have in common. The typical lamprophyres of the region are exceedingly rich in brown mica, which shows a characteristic mode of alteration by internal bleaching with separation of magnetite or limonite; often also the interposition of little wedges of calcite or dolomite. The mica is often accompanied by augite in well-formed crystals but usually quite decomposed, and in the Sedbergh district Dr. Hatch records pseudomorphs after olivine. Original magnetite may occur in variable quantity, but in very many cases is entirely wanting. Apatite in fine needles is universal. The ground-felspars include both monoclinic and triclinic species, the relative proportions of the two not being a character of importance. In the more altered rocks the felspars are not to be made out at all, unless the carbonates have been dissolved out of the mass. Original quartz occurs in the ground-mass of the lamprophyres in the central part of the area only (the Sale Fell intrusion being excluded).

---

[1] It may be remarked here that the lamprophyre of Sale Fell, near Bassenthwaite, which is of a somewhat acid variety, may possibly have had a quite distinct origin.

[2] Bonney (analyses by Houghton), Q.J.G.S., vol. xxxv. p. 165; Rutley, *ibid.* vol. xxxiv. p. 29, and Mem. Geol. Surv. Ingleborough (97 S.W.); Tate, Proc. Yorks. Geol. Pol. Soc. vol. ix. p. 372, vol. xi. p. 311, and Rep. Brit. Assoc. for 1890, p. 814; Hatch, *ibid.* p. 813, and Mem. Geol. Surv. Mallerstang (97 N.W.); Balderston, "Naturalist," 1889, p. 131; Harker and Marr, Q.J.G.S., vol. xlvii. p. 285; Harker, *ibid.* p. 521; see also Teall, "Brit. Petr." chap. x.

Certain porphyritic elements enclosed in the general mass of the rocks, despite their insignificant bulk, are of the highest interest: they are quartz and felspars. Quartz is found in some abundance in the intrusions very near the Shap granite; at greater distances it occurs only sparingly and sporadically, but isolated grains are found even in the dykes at Cronkley in Teesdale. In the acid sills and dykes near the granite the mineral forms sharply-defined pyramidal crystals, in the transitional varieties of rock the crystals are more or less rounded, and in the most typical lamprophyres the quartz occurs in rounded blebs rarely showing any relic of crystal outline. The rounding is clearly due to corrosion by the enveloping magma, and the blebs are commonly bordered by a narrow pale-green rim of rather fibrous hornblende, converted in the more decomposed rocks into a chloritoid substance. Isolated quartz-grains with a corrosion-border of augite or hornblende are known in the lamprophyres of other districts, and have usually been regarded as mechanically caught up from the walls of the dyke. Such a view seems to be merely an *à priori* one, based on the improbability of original quartz-grains occurring in basic rocks, and we shall see that the facts are susceptible of a different reading. It may be noted in passing that similar grains of quartz with a corrosion-border of augite are found in various American olivine-basalts, and are clearly shown to be original constituents.[1]

Very similar in many respects are the phenomena of the porphyritic felspars in our rocks. Both orthoclase and oligoclase are found, as in the Shap granite. In the dykes and sills nearest the granite these minerals occur plentifully; elsewhere they are, as a rule, sparingly distributed. In the intrusions in the Cross Fell inlier, for instance, an ordinary hand-specimen may show perhaps one crystal, perhaps none; in Teesdale the felspars are absent, but near Ingleton, at an equal distance from the granite, they occur in some of the dykes. The crystals of both kinds of felspar are always well rounded by corrosion in the typical lamprophyres, less markedly so in the more acid varieties and the transitional rocks, and quite intact in the normal quartz-porphyries. Within a mile of the Shap granite the sills and dykes sometimes enclose large flesh-coloured crystals of orthoclase identical with those in the granite itself, but more or less rounded as in the dark basic patches of the granite. There is, however, a significant difference. The large orthoclase crystals in the dark patches of the granite have a corrosion-border of plagioclase and quartz: in the lamprophyres this feature is not found, but on the other hand the rounded crystals of oligoclase are often bordered with orthoclase. The enveloping magma was in the former case rich in soda, in the latter case rich in potash. It is likely that in other districts special mineralogical relationships exist between lamprophyres and the plutonic masses near which they occur, but unfortunately the rocks have rarely been studied from this point of view. Doss,[1] in describing the lamprophyres of Dresden, remarks that they enclose orthoclase crystals similar to those of the well-known Plauen'schen Grunde syenite, but rounded by corrosion, and these he regards as mechanically caught up from the syenite. Since the dykes which he studied actually traverse that rock, the explanation is of course a possible one, but it does not appear from his description that the crystals have the form of broken fragments, and the case may well be a parallel to that of the Westmoreland rocks.

---

[1] Iddings, Amer. Journ. Science, vol. xxxvii. p. 208 (1888).

Having in common the general features outlined above, the north-country lamprophyres still show very considerable variations. The silica-percentage in Mr. Houghton's eight analyses ranges from 60 to less than 40, that of the Shap granite being 69. The figures for the more basic rocks are necessarily unsatisfactory, owing to extreme decomposition, some examples having nearly 30 per cent. of carbonates. The associated acid intrusives and transitional varieties ccur well characterized in the centre of the area and to a considerble distance from the granite, but they do not extend so far as the rue lamprophyres. They are well developed in the Cross Fell lier; but some of the acid rocks there are not demonstrably conected with the post-Silurian intrusions, and are possibly Ordovician. n the Sedbergh district the lamprophyres and the acid intrusives re quite distinct, though closely associated, and Mr. Strahan remarks at the former intersect the latter. Rosenbusch makes the same servation in Alsace, and it is probably of some generality. The o sets of rocks, though genetically connected, were derived from ifferent portions of the heterogeneous parent-magma, and the neral rule appears to be that the injection of the quartz-porphyries, icrogranites, etc., slightly antedated that of the lamprophyres. here transitional varieties occur, we may suppose either that they ere supplied from an intermediate portion of the magma-reservoir, that an intermixture of the acid and lamprophyric magmas took lace during the injection. The striking variability of the rocks in me localities must be due to the latter cause, for in some cases the mmingling of the two magmas has been very incomplete. A yke near Gill Farm exhibits abrupt transitions from quartz-porhyry to lamprophyre, such as admit of no other explanation than that offered. Again, Mr. Houghton's analyses of two rocks from the same locality on Docker Fell show a sharp contrast, their silica-percentages differing by more than 10. Professor Bonney concludes that the two specimens cannot be really from the same dyke, but Mr. Collins in his analyses of Cornish lamprophyres shows an even greater difference between two specimens taken *in situ* from one mass.

---

[1] Tsch. Min. Mitth. (2) xi. p. 27 (1890).

A few words on lamprophyres in general will not be out of place at this point. From quite early days such rocks as minette and kersantite have been recognized as interesting types, not very sharply divided from one another, but collectively occupying a position somewhat apart from what may be regarded as more normal igneous rocks. It is true that the principle of classifying rocks by a mere enumeration of their constituent minerals has led some geologists to confuse these types with the mica-bearing syenites and diorites; but such a view is not in harmony with either chemical relationships or geological occurrence. To the field-geologist the rocks in question have always been known as characteristically "dyke-rocks"; more recently they have been shown to occur also as special marginal *facies* of certain deep-seated bodies of rock.

Rosenbusch (1887) distinctly recognizes the individuality of the group, for which he adopts von Gümbel's name lamprophyre.[1] He points out its peculiarities, and separates from the two types already mentioned two others, under the names vosgesite and camptonite, in which the dark mica is more or less replaced by hornblende or augite. He makes, however, a division of the group into a 'syenitic' and a 'dioritic' family, which seems to be quite artificial. It is noteworthy that most of the best known lamprophyres are found in association not with syenites or diorites, but with granites. A glance over Rosenbusch's lists of localities makes this fact at once apparent. In what follows, the lamprophyres will be regarded not as an independent group, but as a special basic modification of rocks of the normal plutonic series. This point of view is scarcely a novel one. Thus we find Hunter and Rosenbusch[2] describing as a new type "monchiquite, a camptonitic dyke-rock associated with the elæolite-syenites" of Brazil and Portugal, while J. F. Williams[3] has given an account of such rocks and others (fourchite and ouachitite) in Arkansas, and has demonstrated their genetic relations with the elæolite-syenites of that state. The varied series of rocks studied by Brögger in the Christiania district seem in several instances to run to lamprophyric modifications, and we may expect much light to be thrown on the subject in that eminent geologist's forthcoming monograph.

In endeavouring to explain the multiplicity of igneous rocks, and the evident genetic relations between widely different types, geologists have been led to speculate on the separation, by gravity or otherwise, of a large reservoir of molten magma into more acid

[1] The name mica-trap evidently cannot be made to cover all the types here included.

[2] Tsch. Min. Mitth. (2) vol. xi. p. 445.

[3] Rep. Geol. Surv. Ark. for 1890, vol. i.

and less acid portions, which, if gravity be the controlling agent, must form upper and lower strata within the reservoir. There can be little doubt that such a hypothesis provides a *vera causa* for many of the phenomena. Now if we compare a more acid with a more basic type in the normal series of igneous rocks, we find certain chemical relations to hold with a high degree of generality. As the silica-percentage diminishes, the proportion of iron-oxides increases (especially at the most basic end of the series), the magnesia increases steadily, the lime increases and then falls off again, the total alkalies diminish, and the proportion of potash to soda also in general diminishes. All systematic treatment of ordinary igneous rocks which is in any degree 'natural' (as opposed to Linnæan) is tacitly based upon these general laws.

We are regarding the lamprophyres as basic modifications of various plutonic rocks, and it is easy to see that tested by the above laws they are abnormal, the exceptional characters being found in the behaviour of the alkalies. This appears on comparing the analysis of a lamprophyre with that of the plutonic rock with which it is certainly or presumably connected. Take, for instance, the biotite-granite of Durbach in the Black Forest, and the remarkable lamprophyre (the durbachite of Sauer[1]) which forms a marginal modification of it. The analyses give—

	Silica.	Soda.	Potash.
Granite	67·70	3·22	5·78
Lamprophyre ...	51·05	1·85	7·24

showing that with a heavy falling off in silica the total of the two alkalies remains closely the same as in the normal rock, while the ratio of potash to soda, instead of diminishing, rises from 1·79 in the granite to 3·91 in the lamprophyre. Again, the quartz-bearing augite-syenite or akerite of Ramnäs passes at its margin into a lamprophyric rock, and the figures are as follows:[2]—

	Silica.	Soda.	Potash.
Akerite	58·48	5·52	3·06
Lamprophyre ...	46·40	4·81	3·84

Here, as before, the total alkalies remain nearly the same, and the ratio of potash to soda increases from 0·56 to 0·80. The augite-minette of the Plauen'schen Grunde may fairly be compared with the syenite which it cuts through, and the results stand thus—

	Silica.	Soda.	Potash.
Syenite	59·83	2·44	6·57
Lamprophyre ...	50·81	1·01	7·01

the total alkalies only falling from 9·01 to 8·02, and the ratio of potash to soda rising from 2·69 to 6·94.

Judged by these examples, the lamprophyres would seem to be special basic modifications of their parent-rocks in which, with a greatly diminished percentage of silica, the total alkalies show little change, while potash becomes more abundant at the expense of soda. We have selected, however, cases of lamprophyres in the closest connexion with their parent-rocks; going to greater distances, we find the total alkalies falling off, but still far in excess of the amounts proper to rocks of like silica-percentage. The relation between the two alkalies noticed above is by no means universally found in the lamprophyres (cf. those of Cornwall), but it is certainly very common and characteristic. The Shap granite has 8·22 per cent. of alkalies. In Mr. Houghton's eight analyses of the dykes the figure varies from 7·99 to 4·52. The ratio of potash to soda in the dykes ranges from 9·51 to 0·93, and is in every case but one higher than the ratio in the granite (1·01). It is particularly high in the most basic of the lamprophyres.

---

[1] Mitth. Grossherz. Baden Landes, vol. ii. p. 258.

[2] Brögger, *Syenitpegmatitgänge*, p. 49.

The chemical peculiarity of the lamprophyres, as compared with other rocks of like basicity, consists then in their relatively large content of alkalies, and in particular of potash. The mineralogical peculiarities of the rocks are, of course, simple consequences of this. The abundance of potash enables nearly all the magnesia and iron-oxides in the magma to be built up into brown mica, so that augite and hornblende occur only as minor accessories, and original free iron-ores are in very many cases not formed. A large part of the potash being taken up in the mica, it follows that the predominance of orthoclase or plagioclase among the ground-felspars will not be related in any very simple manner to the proportions of the two alkalies in the bulk-analysis, and a classification of the rocks based on the dominant species of felspar will not be a natural one. Further, in so far as any such relation holds, the plagioclase-rocks will, broadly speaking, be more acid than the orthoclase-rocks derived from a similar parent-magma. It may be noticed in the analyses of the typical European rocks that the kersantites are more acid than the minettes. Another consequence of the abundance of the basic silicate mica in the ordinary lamprophyres is that free quartz is often formed in rocks with not much more than 50 per cent. of silica.

If the more ordinary types of lamprophyres are to be regarded as specialized *facies* of granites and syenites—the conclusion to which the foregoing remarks tend—it may be asked whether other families of plutonic rocks may have like modifications connected with them. A few peculiar rocks have been described which might possibly be considered in such a light. I would doubtfully instance Koch's[1] olivine-mica rock forming a small dyke in Kaltenthal in the gabbro-district of Harzburg. This may be compared with the immediately adjacent gabbro of Ettersberg, analysed by Streng, as being conceivably a lamprophyre (in the extended sense) of that rock, thus:—

	Silica.	Soda.	Potash.
Gabbro	50·09	1·39	0·83
Lamprophyre?...	34·98	0·17	5·42

Here the large quantity of potash in the second rock is very striking. In the other constituents the relation of the rock in question to the gabbro is that of an ordinary ultrabasic to a basic type.

Returning to the rocks of the North of England, the question naturally arises: how did the lamprophyric magma become abormally enriched in potash as compared with ordinary basic segre- ations? On this point some suggestions may be offered. We may magine beneath the area where the lamprophyres are now exposed, r beneath the central part of it, a deep-seated reservoir of molten nagma which was partially separated under the action of gravity, he heavier basic portion forming the lower strata. In this magma, s it cooled, the earlier products of consolidation crystallized out, he most important of these early products being the large crystals f orthoclase. It is a known fact that felspar-crystals will sink ven in a basic rock-magma, and thus as the crystals formed, they nust have accumulated at the bottom of the reservoir, and thus nodified the total composition of the lower basic strata. The xamination of the Shap granite proves that a certain portion of the uartz, the sphene, and especially the apatite crystallized out before r simultaneously with the large felspars, and these too would sink o the bottom. The felspars and quartz have been dissolved by the asic magma, but their elements would not be redistributed through he whole magma in the reservoir, except in so far as the dissolution f the crystals was concurrent with their accumulation. The process f solution seems to belong to a later stage, that of a relief of pres- ure when the injection of the dykes took place. Since the por- hyritic felspars occur plentifully in the Shap granite, we must uppose that their sinking to the bottom was finally arrested by general consolidation of the magma, or at least a certain degree of iscosity in any part which remained molten. Subsequently to this ame a partial refusion of the whole and the intrusion of the granite nto its present position, closely followed by the injection of the cid dykes and sills and almost immediately the lamprophyres. The diminutive size of the corroded felspars in the latter rocks robably indicates that many others have been entirely dissolved in he containing magma, and this solution is most reasonably referred o the epoch of the injection of the dykes. It corresponds to the 'resorption" phenomena in the intratelluric hornblende and biotite f many andesites, etc., effects ascribed to the relief of pressure in he process of extravasation of the lavas. Felspar-crystals, as has een stated, are found, though as a rule sparingly, in some lam- rophyres at a considerable distance from the centre of the area; ut, in view of the narrowness of many of the dykes, it seems pro- able that their transportation has been in some measure checked by sifting or filtering action.

---

[1] Zeits. deuts. geol. Ges. vol. xli. p. 163 (1889).

The above considerations may appear very speculative; but in eality, if the magma-reservoir be granted, they scarcely go beyond nown facts. If some such hypothesis be found satisfactory in the rea considered, it may possibly have a wider application. Certainly he association of mica-lamprophyres with porphyritic granites in umerous districts is rather striking. The porphyritic felspars, owever, must not be regarded as essential. All that is requisite is that some constituent rich in alkali should crystallize out at an early stage in a magma more or less separated under the action of gravity. Such constituent may be in different cases a felspar, a felspathoid (leucite, sodalite, etc.), or a mica, and there may or may not be any undissolved relics of it in the lamprophyre as finally consolidated.

One other remark may be made in conclusion. In rocks containing abnormally large proportions of potash and soda, and having at the same time plenty of alumina, it should not be surprising to find occasionally minerals richer in alkali than the felspars. Now at Cronkley, on the banks of the Tees, all the dykes contain a mineral which in thin slices shows hexagonal or quadrangular outlines, with a dark border and nucleus. The sections have no very definite action on polarized light, and seem to be more or less completely converted into obscure decomposition-products. Mr. Rutley regarded the mineral as decomposed garnet, but if it occurred in a phonolite or leucitophyre it would probably be put down confidently as nosean. Without expressing an opinion on this point, I will observe that in the most easterly dyke, where the mineral in question is most abundant, there occurs another with square contour, bright blue colour, and single refraction, which I can refer to nothing but haüyne.

III.—AN IMPROVED METHOD OF TAKING IMPRESSIONS OF FOSSILS, ETC.

By J. G. GOODCHILD, F.G.S.
of Her Majesty's Geological Survey; Lecturer on Palæontology at the Heriot Watt College.

PALÆONTOLOGISTS and others concerned with fossils often have need of some method of taking impressions of fossils, which shall at the same time be simple and efficacious, and shall also be of such a nature as not to cause injury of any kind to the original. Many different processes have been tried, with varied success. The following method has stood the test of application to a wide range of subjects, and has answered its purpose well in the hands of a considerable number of workers:—

The only outfit required is a small roll of thin tinfoil of ordinary quality, a small plate-brush, neither too hard nor too soft, a bottle of shellac varnish, and some paraffine wax, with a night light or some such means for melting it.

If the fossil is not in too high relief, say a fossil fish, or such a plant as a Coal-measure fern, all that is needed is to cut a piece of foil rather larger than the specimen, then to press it gently, with the finger tips at first, into all the larger depressions, beginning at the middle and working outwards towards the edge all round. Then, keeping the fingers extended over the impression, go over the whole thing with the plate-brush, using it as gently as possible, and with only a very slight lateral movement. After a few seconds treatment of this kind an almost exact counterfeit of the fossil will appear—even some of the very finest sculpturings being distinctly visible on the upper surface of the foil.

When that stage is reached, the foil should be lifted very gently at each corner so as to free it from any projecting or undercut points. Herein lies the special value of the tinfoil process, inasmuch as *this material* does not enter the undercut parts as modelling wax, gutta percha, etc., are apt to do; consequently when the tinfoil is withdrawn it never drags away part of the fossil. When the foil is loosened so that it will lift off easily, it should be gently pressed back again with the brush so as to make it resume its proper shape. Then, if the subject is tolerably flat, and no holes have been torn in the foil, it may be lifted off at once. To fix it, the most important part of the process, it will generally suffice to pour on to the impressed, or under, side, sufficient shellac varnish (which should be of a consistence between that of cream and that of treacle) to float the whole surface. This should not be distributed by means of a brush, but by simply turning the impression about until the surface is covered by the varnish. In a few minutes this will be dry enough to lay by. A second coating, later on, will render it quite hard enough to stand ordinary handling without any risk of altering its shape.

Should the fossil be in somewhat higher relief, so that a few holes are torn in the foil, the best mode of treatment is to go over the upper surface of the "counterfeit" with a thin coat of melted paraffine while it is on the original. The wax chills at once into a firm mass, and the foil may be lifted off with ease. Then the back is floated with varnish as before. When this is set, all that is necessary to do is to put the foil into water sufficiently hot to melt the paraffine, which at once floats off, leaving the foil quite bright, as before.

In the case of objects in very high relief more care is, of course, required; but the process answers very well even then. Thanks to the courtesy of Dr. Traquair, I have been enabled to make tinfoil counterfeits of a large number of fossils from the collection in the Edinburgh Museum of Science and Art, many of them in high relief, by this process; and, with a little management, have been able to make them retain the form of the original perfectly, by coating the inside of the impression with cotton-wool, and flooding this with varnish as before.

In some respects impressions made by this process are even better than the originals; for the metallic lustre of the tinfoil causes the light to be reflected from the salient parts of the copies much more strongly than from the originals. Indeed, when the part of the foil representing the matrix is painted a dead black, I find it much easier to draw from the foil impressions than from the originals.

Another advantage presented by this method is that any number of copies can be made in a very short space of time; and in lecturing on Palæontology in Edinburgh, I am able in the majority of cases to place in the hands of each student a reliable copy of the fossil I am describing, and in this way he is able to make more satisfactory progress than would otherwise be possible.

Lastly, as Curator of a Collection embracing nearly twenty thousand specimens of fossils, I am occasionally called upon to lend out specimens for description. In all such cases my plan is to take a careful tinfoil counterfeit of the original before it goes out, and this, with the register entry, places the exact nature of the loan on record in a manner that leaves nothing to be desired.

IV.—ON THE NATURE AND ORIGIN OF EARTHQUAKE-SOUNDS.

By CHARLES DAVISON, M.A.;
Mathematical Master at King Edward's High School, Birmingham.

THE sound-phenomena accompanying earthquakes have not often been made the subject of special investigation; and, consequently, their value and significance may have been somewhat underrated. I believe that much remains to be done, that many observations must yet be made, before the problem of their origin can be regarded as completely solved; but the facts already known seem to me sufficient to show that the inquiry is one full of interest and worthy of development beyond that here attempted.

NATURE OF EARTHQUAKE-SOUNDS.

1. *Character of the Sound.*—The sound is sometimes of so unusual a character that it is difficult to describe it exactly, but generally it more or less resembles one of the following: (1) *Thunder*—either a clap or a prolonged peal, the rolling of distant thunder, or thunder when it dies away as echoes among mountains. (2) *The rumbling of passing carriages, wagons, etc.*—driven rapidly over a hard road, over pavement, stones, a wooden or stone bridge, or under a gateway, a heavy traction-engine passing, a couch or heavy chair dragged across the floor of a room above, a train rapidly approaching or rushing through a station, the jerking of a train brought suddenly to rest, the rumbling of wagons laden with planks, stones, or heavy casks. (3) *The firing of cannon*—either one or several in quick succession, a heavy and well-sustained fire of artillery, a distant cannonade. (4) *An explosion*—a blast in a quarry, a colliery explosion, the blowing-up of a magazine or powder-mine. (5) *The fall of heavy bodies*—a cartload of stones suddenly emptied, a heap of rubbish shot down, a large quantity of shingle poured on to a house-roof from a great height, the fall of houses, snow sliding down the roof of a house and falling on the ground, an avalanche of snow, the fall of heavy furniture, a signal-post or a heavy mattrass, a cannon-ball rolling downstairs. (6) *Wind*—a blast or sudden gust, the roar of wind in a storm, wind among trees, the suppressed roaring of wind entering a gorge, a chimney on fire. (7) *Miscellaneous*—a hissing noise like that of red-hot iron plunged into water, the rushing of water, the cracking of a wall, a door violently slammed, the breaking of glass, a horse loose in its stall, the muffled rat-a-plan of heavy side-drums, a burst of applause in a room overhead like what newspapers call "loud and prolonged cheering."[1]

In a few cases (the breaking of glass, for example, or the rustling of wind among trees), the sound is a comparatively high one; but, most frequently, it is *a deep rumbling noise, sometimes perhaps not very much above the lower limit of audibility.*

---

[1] This list, by no means an exhaustive one, is compiled from 389 accounts, obtained from the third part of Mallet's Catalogue of Recorded Earthquakes (Brit. Assoc. Rep. 1854), Meldola and White's East Anglian Earthquake of 1884, and the notes communicated to me by correspondents during my study of the British earthquakes of the last three years. Out of the above number, comparisons are made to thunder in 97 cases, to the passing of carriages, etc., in 130, the firing of cannon in 53, explosions in 45, the fall of heavy bodies in 33, wind in 27, and to various sounds under the last heading in 14 cases.

2. *Variations in Intensity and Pitch.*—The frequent use of the words "rolling" and "rumbling" in describing earthquake-sounds, as well as comparisons to thunder, etc., shows that the sounds do vary both in intensity and pitch.

On a few rare occasions, the sound is said to begin or end abruptly, the intensity being at, or not far from, its maximum. But most frequently, almost invariably I believe when the observation is complete, *the sound begins faintly, becomes continually louder, and then gradually dies away.* As might be expected, this change in intensity is most marked in the immediate neighbourhood of the epicentrum; near the limits of the sound-area it is hardly perceptible, and the sound there resembles closely the low roll of distant thunder.

Records of variation in pitch are far from numerous. The following may be given as examples: (1) 1791, Nov. 27, Lisbon. Two shocks, one five minutes after the other. The second and more violent shock "was attended with a hissing noise like that of red-hot iron quenched in water, and ended with an explosion like the report of cannon."[1] (2) 1884, April 22, Essex. At Summerhill, about 1½ miles N.W. of Colchester, "suddenly a jingling noise was heard, which developed rapidly into a deep underground rolling noise." The beginning of the sound seems to have preceded the beginning of the shock, and, at two other places in the neighbourhood, this was the case.[2] (3) 1890, Nov. 15, Beauly, near Inverness. "There was a great noise, as if huge quantities of shingle were being poured upon the house-roof from a considerable height, the sound deepening to that of heavy artillery." The evidence is too scanty to support any certain conclusion, but it seems to afford some grounds for believing that *the sound becomes deeper as it increases in intensity*; in other words, that the period of vibration increases with the amplitude.

RELATIONS OF THE SOUND TO THE SHOCK.

1. *With regard to Time.*—Professor Milne, in an interesting "Note on the Sound Phenomena of Earthquakes,"[3] remarks that in the majority of cases, the sound precedes the shock rather than follows it; and he conjectures that the sound, when it does follow the shock, may be an independent phenomenon.[4]

In order to determine the relative frequency of the different cases, I examined the accounts given in the third part of Mallet's "Catalogue of Recorded Earthquakes" (*i.e.* those occurring between August 26, 1784, and the end of 1842), in which the time-relation of the sound to the shock is definitely stated. There are in all 423 records. The sound is said to have

---

[1] Mallet, Catalogue of Recorded Earthquakes, Brit. Assoc. Rep. 1850, p. 30.

[2] Meldola and White, East Anglian Earthquake of 1884, pp. 55, 57, 58.

[3] Japan Seismol. Soc. Trans. vol. xii. pp. 53-62.

[4] There can be no doubt that this is frequently the case. See, for instance, M. Boussingault's paper, "Sur les détonations constatées pendant les tremblements de terre," Comptes Rendus (July 18, 1881), vol. 93, pp. 105-6; also Humboldt's Cosmos (Bohn's edition), vol. i. pp. 203-4.

Preceded the shock in	100 cases.
Accompanied or attended it in	307 ,,
Followed it in	9 ,,
Preceded and accompanied it in	2 ,,
Accompanied and followed it in	2 ,,
Preceded, accompanied and followed it in	3 ,,

It must be admitted that the phrase "accompanied" or "attended," singly, is a very vague one. As a general rule, it only means that the sound was heard at about the same time that the shock was felt; hardly ever, perhaps, that the beginning and end of both sound and shock were coincident. It cannot, then, be taken to exclude cases in which the sound may have overlapped the shock at either end or both. The meaning of the terms "preceded" and "followed" is less ambiguous, though not free from doubt. But, so far as regards the earthquakes recorded by Mallet, it is clear that the beginning of the sound must have preceded that of the sensible shock much more frequently than the end of the sound followed that of the shock.

Turning, however, from these earthquakes, which are, as a rule, of considerable intensity, to shocks of slight intensity and short duration—shocks, for example, like those generally felt in this country—it will be found that the comparative rarity of subsequent sounds is not so strongly marked. In studying the Inverness earthquake of November 15, 1890, I received definite replies to the question on the time-relations of the shock and sound from 64 places, with the following results.[1] The sound is said to have

Preceded the shock at	20 places.
Accompanied it at	26 ,,
Followed it at	1 ,,
Preceded and accompanied it at	5 ,,
Accompanied and followed it at	5 ,,
Preceded, accompanied and followed it at... ...	7 ,,

In the other British earthquakes which I have studied the observations on this point are less numerous, but they are sufficient to show that, in certain parts of the disturbed area at any rate, the sound frequently continues to be heard after the close of the sensible shock.

2. *With regard to the Maximum Intensity of the Shock and Sound.*—It has been already remarked that, in British earthquakes, the sound increases in intensity, to a maximum, and then dies away. Now, it appears, from a large number of observations, that *it is just at the moment when the sound is loudest that the principal vibrations are felt.*

This fact was noticed fifty years ago by Mr. David Milne (afterwards Milne-Home) in a valuable series of papers on the earthquakes of this country. In summarizing their principal features, he remarks that there appear to be two distinct sensations, a tremor and a violent blow or concussion, the latter known in Comrie and the neighbourhood as the "thud." "The tremulous or trembling motion," he says,

---

[1] Quart. Journ. Geol. Soc. 1891, p. 623.

'is always perceived. When the blow occurs it is generally in the midst of the tremors, and at the moment that they are the most intense, and accompanied with the loudest noise."[1]

In studying the more recent British earthquakes, I have received many observations on this point, of which the following examples may be given: (1) The epicentrum of the Kintyre earthquake of July 24, 1890, was a few miles from Clachan: at which place the shock began with a series of slight tremors lasting for twenty seconds. These tremors gradually "increased in intensity until a vibration was felt like what would be caused by a heavy stone falling from a very great height," and this vibration, again, was followed by tremors lasting for five seconds. During the whole time of the tremulous motion a sound was heard like the crashing of falling stones, and, coincidently with the principal vibration, a dull "thud" as of a suppressed explosion.[2] (2) In nine different accounts of the Inverness earthquake of November 15, 1890, a similar phenomenon was described. At Boleskine, for instance, an observer "heard a sound as if a heavy train was approaching, ... it gradually got louder and louder until it seemed to go right through the house, shaking the pictures and china ornaments on the walls." (3) Still more to the point, perhaps, is a remark made by an observer at Boscastle (Cornwall) of the earthquake felt there on March 26, 1891. This earthquake consisted of two distinct shocks separated by an interval of a few seconds. The sound was loudest just at the times when the shocks were felt, and continued, though more faintly, during the whole of the interval between them.

A. RELATIONS OF THE SOUND TO THE DISTURBED AREA.

1. *Variations in the Nature of the Sound and in its Relation to the Shock throughout the Disturbed Area.*—In every earthquake, of which sufficiently numerous observations have been made, the sounds vary greatly throughout the disturbed area, not only in intensity, but also in character, duration and relation to the shock.

In the great Neapolitan earthquake of 1857, so ably studied by the late Mr. Mallet, the sounds were heard over an area roughly elliptical in form, its longer axis being directed about N.W. and S.E. All the observers towards the northern and southern extremities of this area described the sound as "a low, grating, heavy, sighing rush, of twenty to sixty seconds in duration, some thinking that it was also a sort of rumbling sound, but with none, a distinct, well-defined explosion, or several in succession." Those "who were situated towards the middle of the sound-area, and towards its east and west boundaries, on the contrary, very generally described the sound, as something of the same character as to *tone*, but with more rumbling . . . . and as shorter and more abrupt both in commencement and ending, and in duration."[3]

The Inverness earthquake of November 15, 1890, was, I believe,

---

[1] Edinburgh New Phil. Journ. (1841), vol. xxxi. p. 261.

[2] GEOL. MAG. (1891). Vol. VIII. pp. 453-4.

[3] 'The Neapolitan Earthquake of 1857,' vol. ii. p. 288.

caused by the slip of a fault running approximately north-east a
south-west, and hading to the north-west, the slip extendi
probably over a horizontal distance of several miles, and bei
greatest towards the south-west. Now, "the 25 places at which t
sound preceded, or preceded and accompanied, the shock, though
confined to any one part of the disturbed area, are mostly situa
in the district north-east of the epicentrum," while five of the
places at which the sound followed, or accompanied and follow
the shock are "either south-west of the epicentrum, or close to
on the north-west side, *i.e.* just where the intensity is greatest."

2. *The Extent of the Sound-area is independent of that of*
Disturbed Area.—Humboldt, in his "Cosmos," remarks that "
intensity of the hollow noise which generally accompanies an ear
quake does not increase in the same degree as the force of
oscillations;"[1] and it has also been observed that, in very viol
earthquakes, the sounds are confined to a comparatively small a
in the neighbourhood of the epicentrum. The Neapolitan earthqu
of 1857, for instance, disturbed the whole of the Italian penins
south of lat. 42°, being felt nearly as far as Rome, while the sou
were only heard within an area containing 3300 square miles im
diately surrounding the epicentrum.

The slighter shocks of this country also afford good examples.
the East Cornwall earthquake of October 7, 1889, and the Invern
earthquake of November 15, 1890, the sounds were heard at nea
all the places where the shocks were felt; though it is of cou
possible that in these cases the coincidence of the sound-area
the disturbed area may have been apparent rather than real.
Edinburgh earthquake of January 18, 1889, disturbed an ellipt
area, about 30 miles from north to south, and 26½ miles from
to west; the length of the sound-area was about 25 miles from no
to south, its breadth could not be exactly determined. The
turbed area of the Lancashire earthquake of February 10, 1889,
approximately circular, being 56 miles from north to south and
miles from east to west; the sound-area was very nearly circ
and 29 miles in diameter.

These examples are sufficient to show that the extent of the sou
area bears no constant relation to that of the disturbed area. A
general rule, we may say that, the more intense the earthquake,
less is the ratio of the extent of the sound-area to that of
disturbed area; but this is by no means always true.

The limiting case, in which sounds are heard without
perceptible shock, is one of which records are frequent. On
the most remarkable is that described by Humboldt in his "Cosm
where he refers to the subterranean thunderings (*bramidos y tru*
subterraneos) of Guanaxuato on the Mexican plateau. "The noi
he says, "began about midnight, on the 9th of January, 1
and continued for a month. . . . . From the 13th to the 16t
January, it seemed to the inhabitants as if heavy clouds lay ben
their feet from which issued alternate slow rolling sounds and s

---

[1] Vol. i. p. 203.

quick claps of thunder. The noise abated as gradually as it had begun. It was limited to a small space, and was not heard in a basaltic district at the distance of a few miles." "Neither on the surface of the earth," he adds, "nor in mines 1600 feet in depth was the slightest shock to be perceived."[1]

The following accounts throw additional light on the subject: (1) At East Haddam, Conn., U.S.A., on May 16, 1791, at 8 p.m., two shocks were felt in quick succession, of which the first was the more violent. Soon after, these were followed by a third and slighter shock, and this, again, by nearly one hundred feebler shocks throughout the night. "Subterranean noises are constantly heard at East Haddam, whence its Indian name, Morehemodus, or the place of noises. After this shock, both noises and shocks became less frequent." In several cases noises were heard about this time unaccompanied by any shock. (2) In Piedmont, on April 2, 1808, at 5.43 p.m., an earthquake of intensity VIII., according to the Rossi-Forel scale, was felt, its centre of disturbance having apparently been at Pignerol. This was followed by a large number of slighter shocks (Mallet records about 300) until July, 1809, after which they became less frequent. At Barga, La Tour and other places in the district, subterranean noises were often heard without any accompanying shock. (3) In the island of Meleda, in the Adriatic, noises were heard during a still longer period, from March, 1822, to February, 1825. Mallet remarks that they "do not seem to have been accompanied by any true earthquake shocks, or, at least, any such felt were extremely slight;" but, according to Humboldt, they were "occasionally accompanied by shocks." (4) At St. Jean-de-Maurienne (in Savoy) and the surrounding district, 49 principal shocks were felt between October 4 and December 28, 1839, "and many more indistinct ones which were not recorded. . . . . They were generally preceded or accompanied by subterranean noise, and sometimes this noise was heard without any sensible shock." (5) On October 3, 1839, a remarkable series of shocks commenced at Comrie, in Perthshire. "The shocks were in general very slight, but sometimes rather severe, and were generally accompanied by subterranean noises, variously described as like distant thunder, the reports of artillery, the sound of a rushing wind, etc. The noise . . . . was often heard without any sensible shock at the time." It would appear from these examples that *subterranean sounds without any accompanying earthquake especially characterise those districts where slight shocks are very frequently felt*, as if the sounds and shocks were manifestations, differing only in degree and the method in which we perceive them, of one and the same class of phenomena.[2]

[1] Vol. i. p. 205-6.

[2] Mallet's Catalogue of Recorded Earthquakes, Brit. Assoc. Rep. 1854, pp. 28, 31, 68-84, 138, 162, 162, 166, 288, 290; Humboldt's Cosmos, vol. i. p. 205, footnote. Possibly also of seismic origin are the phenomena known as the Barisál Guns, "sounds resembling the fire of heavy cannon at a distance, which are heard at various points in the Delta of the Ganges and Brahmaputra, and in the hills to the north of it" (Brit. Assoc. Rep. 1891).

On the other hand, there is the well-known instance mentioned by Humboldt, of no sounds at all being heard during a very violent earthquake. "I have ascertained with certainty," he says, "that the great shock of the earthquake of Riobamba (4th February, 1797) —one of the most fearful phenomena recorded in the physical history of our planet—was not accompanied by any noise whatever;" and again, later on, speaking of the same shock, he says: "The earthquake itself was neither accompanied nor announced by any subterranean noise."[1] This is the only example I know of, and it is obvious that a satisfactory theory of earthquake-sounds must account for the commonness of the one extreme case and the rarity of the other.

B. 3. *The Sound-area is not necessarily concentric with the Disturbed Area.*—The excentricity of the sound-area is one of the most important phenomena connected with earthquake-sounds, and it was the recognition of this in the cases of the Edinburgh and Lancashire earthquakes of 1889 that led to the theory explained in the latter part of this paper. I will here give a short outline of the principal facts, referring for a fuller description of the sound and other phenomena of these shocks to my paper, "On the British Earthquakes of 1889."[2]

Edinburgh earthquake of January 18, 1889.—The epicentrum is situated about 3 miles W. 42° S. of Balerno, and the centre of the sound-area about 2½ miles to the south or south-east of the epicentrum. Both points lie on the north-west or downthrow side of the first of the great faults to the north-west of the axis of the Pentlands; and it is very probable that the earthquake was due to the impulsive friction arising from a slight slip of this fault at a spot not far from the middle of its course as laid down upon the Survey map, a slip which increased the throw of the fault. The centre of intensity of the seismic focus was probably at a point on the fault at the depth of about eight miles. The simple character and short duration of the earthquake show that the horizontal length of the area over which the slip took place was not great, perhaps not more than a mile. Now, the centre of the sound-area is close to the line where the fault meets the surface, nearer to it by about 2½ miles than the epicentrum; and this shows that *the sound-vibrations must have chiefly proceeded from a part of the focus nearer the surface than did the vibrations of larger amplitude which caused the shock itself.*

Lancashire earthquake of February 10, 1889.—The epicentrum of this earthquake is about two miles N.N.E. of Bolton, and on the north-east or downthrow side of the great Irwell valley fault. About 3¼ miles S.S.W. of the epicentrum, and apparently at a short distance on the upthrow side of the same fault, is the centre of the sound-area; but its position cannot be determined with any great accuracy, for I know of no places where the sound was certainly not heard. The evidence obtained is, I believe, sufficient to show that the earthquake was caused by a slip of the fault referred to, the slip being one that increased its throw; that the centre of intensity of the seismic focus was at a depth of about 3¾ miles; that the horizontal length of the area over which the slip took place was short, perhaps less than a mile. Remembering the uncertainty in the position of the centre of the sound-area, I think we may infer that, in this earthquake also, the sound-vibrations originated at a part of the fault nearer the surface than the centre of the seismic focus.

---

[1] Cosmos, vol. i. p. 203, and vol. v. p. 172. Mallet, in his Catalogue, occasionally indicates an earthquake as having been unaccompanied by sound, but it is not certain that his observations were drawn from a large part of the disturbed area. Prof. Milne states that sounds are not often heard during the Japanese earthquakes, but many of these earthquakes originate under the sea, and the places where they are observed in Japan may possibly be outside the sound-areas.

[2] GEOL. MAG. (1891), Decade III. Vol. VIII. pp. 57, 306, 364, and 450.

C. ORIGIN OF EARTHQUAKE-SOUNDS.

Within the last few years, the numerous seismographic records made in Japan by Profs. Milne, Ewing and Sekiya have thrown considerable light on the nature of earthquake-vibrations. It is chiefly, however, that part of the series including, and bordering on, the sensible vibrations which has been studied: for, as Prof. Milne remarks, "many earthquakes, like the solar spectrum, have extremities which are difficult to investigate."

The records referred to show that earthquakes usually begin with a series of very small and very rapid tremors, from six to eight ccurring every second; that, after lasting perhaps for many seconds, hey become less rapid, and then, without any break of continuity, follow the sensible vibrations of larger amplitude and longer period, t the rate of about three to five per second. One or more of these, ttaining an amplitude still greater and having a period of one r two seconds each, constitute what are generally known as the rincipal shock or shocks. The earthquake closes with vibrations f smaller amplitude, but "which are so long in period, that the ointers and steady points of our seismographs do not give a relative novement, but follow these back and forth movements as a whole, nd no record is obtained." On the other hand, they fail to register he commencing tremors of the earthquake on account of their exremely small amplitude.

Now, for the part of the series preceding and including the rincipal shocks, the period of the vibrations increases with the mplitude; and it is therefore not unreasonable to conclude, as rof. Milne has done, that the first tremors recorded are "the coninuation of still smaller and more rapid movements, which on ccount of want of sufficient multiplication in our instruments have ever yet been rendered visible." And it is to these supposed very apid vibrations, which form the front portion of an advancing earthuake, that Prof. Milne attributes the origin of the earthquake-sounds. umming up, he says: "The majority of earthquake-sounds are roduced by short period surface vibrations of the earth and these ibrations are portions of and continuous with the earthquake that ccompanies the sound." [1]

---

[1] Japan Seismal Soc. Trans. vol. xii. pp. 107 and 60.

Throughout the remainder of this paper, I shall conclude that Prof. Milne's observations do, as he suggests, imply the existence of preliminary vibrations short enough in period to give rise to the phenomena of earthquake-sounds; and I shall endeavour now to show how these vibrations originate, and at the same time to account thereby for the different sound-phenomena described above.

To give definiteness to the theory, I shall take the case of an earthquake produced, as I believe most non-volcanic earthquakes are produced, by the friction due to the slipping across one another of the two rock-surfaces of a fault.

The seismic focus, or slip-area, may be of very considerable dimensions, sometimes fifty miles or more in length. The intensity of a shock does not, however, depend so much on the size of a slip-area as on the maximum amount and short duration of the slip. Now, it is evident that the amount of the slip must vary greatly throughout the slip-area, but it will be sufficient to consider only the simplest case, that in which the amount of slip is a maximum in a certain central region, and diminishes gradually until it is zero along the margin of the seismic focus; though the faces of a fault not being smooth planes, there will probably be several or many such regions of maximum slip.[1]

Now, since up to a certain point the period of a vibration increases with its amplitude, and since the initial amplitude of the vibrations must depend on the amount of slip producing them, there will, from all parts of the slip-area considered, proceed vibrations varying, not only in amplitude, but also in period; and along the borders of the slip-area, where the fault-slip dies away, these vibrations may be small enough, and consequently rapid enough, to produce the sensation of sound. I imagine, then, that *the sound-phenomena accompanying earthquakes are produced by the minute vibrations coming chiefly from the upper and lateral margins of the slip-area.*

For brevity, I will give the name of the "sound-focus" to that part of the slip-area or seismic focus from which the sound-vibrations come.

The boundary-line between the sound-focus and the rest of the seismic focus is not a definite line. Its position varies with the lower limit of audibility of each observer, so that at exactly the same spot two observers might differently estimate the duration of the sound. But, neglecting for our present purpose this personal equation in the observers, it is evident that the position of the boundary-line referred to depends only on the position of the points on the slip-area at which the amount of slip is just small enough to produce vibrations which may be heard, that it is independent of the maximum amount of slip within the seismic focus. Now, other conditions being the same, the dimensions of the sound-area are determined by the intensity of the vibrations which are just perceptible as sound, and those of the disturbed area by the maximum intensity of the initial earthquake-vibrations; and therefore *the extent of the sound-area must be independent of that of the disturbed area.*

---

[1] The rumbling or rolling character of the sound, though arising partly no doubt from interference, may also in part be due to the existence of several regions of maximum slip.

It is possible that from the lower margin of the slip-area sound-vibrations may proceed; but, so far as regards the sounds heard at the surface, the vibrations proceeding from the upper and lateral margins must be most perceptible. The centre of intensity of the sound-focus must therefore, as a rule, be within the upper margin of the seismic focus, i.e. *the sound-area is not concentric with the disturbed area, and the centre of the former is nearer to the fault-line than the centre of the latter.*

Throughout the greater part of the sound-area, the vibrations first perceived must be those from the upper or lateral margin of the seismic focus, i.e. *the beginning of the sound must generally precede the beginning of the shock.* There will, however, be a small part of the disturbed area, that immediately surrounding the point where the normal to the slip-area meets the surface, where the shock may be felt first: unless, indeed, the fault-slip does not take place instantaneously, but, commencing very slowly, initiates a series of short-period vibrations from the whole slip-area before the true earthquake vibrations are produced. In this case, however, the excentricity of the sound-area would be hardly perceptible.

At most places within the sound-area, then, the sound will be first heard, due to vibrations proceeding from the nearer lateral margin of the seismic focus. The sound will become gradually louder and deeper until its intensity is a maximum, the vibrations then coming from the boundary-line between the sound-focus and the rest of the seismic focus. Soon after this, the sensible shock will be felt, due to vibrations proceeding from that part of the focus where the amount of slip is greatest, the sound continuing for all or part of the time, owing to the arrival of vibrations from the upper margin of the slip-area. And, lastly, after the sensible shock ceases to be felt, will be heard the sound coming from the further lateral margin of the slip-area, provided that margin be not too distant, the sound becoming higher as it dies away.

In the neighbourhood of the boundary of the sound-area, the sound-vibrations from the further lateral margin of the seismic focus will be imperceptible, and the sound will be heard only preceding, or preceding and accompanying, the shock; and this may in part account for the comparative rarity of the records of the subsequent sound-phenomena.

Again, in most British shocks, the part of the focus from which the sensible vibrations come is of small magnitude, so that *only one or two principal vibrations are produced, and these are felt just at the time when the sound is loudest.*

If the sound-vibrations first or last perceived be those which come from the boundary between the sound-focus and the rest of the seismic focus, the sound will begin or end abruptly. But observations of such a phenomenon must be rare.

The different relations between the dimensions of the sound-area and the disturbed area may be attributed to variations in the amount of slip throughout the seismic focus. (1) If the amount of slip be everywhere very small, the sound-focus may occupy the whole of the slip-area, and thus sound may be the only phenomenon perceptible at the surface to the unaided senses. This seems to have been frequently the case amongst the series of small slips which produced the numerous slight shocks at Comrie, Pignerol, and elsewhere. (2) If the sound-focus occupy nearly the whole of the slip-area, the amount of slip in the rest of it being small, but still great enough to produce a slight shock, then the sound-area and the disturbed area might be approximately co-extensive, or the sound-area might in places entirely overlap the disturbed area. (3) But very frequently, especially in the more pronounced seismic areas, the maximum amount of slip within the seismic focus will be so great that the disturbed area will be large compared with the sound-area, and, in severe earthquakes, will extend far beyond it. (4) Lastly, the slip might take place suddenly, and its amount be so great, that the sound-focus might be confined to the lateral margins of the slip-area. The slip would then extend up to the surface of the earth, and, if great enough, might be traceable there as a difference of elevation on the two sides of the fault-line; the sound-area would consist of two detached portions at some distance from the region of maximum disturbance, and the sounds consequently might escape observation and record.

But while earthquakes of such extreme intensity are very unusual, very slight slips must frequently take place; so that earthquake-sounds without an accompanying shock should be of far more common occurrence than earthquakes without attendant sounds.

V.—NOTES ON THE ASH-SLATES AND OTHER ROCKS OF THE LAKE DISTRICT.

By W. MAYNARD HUTCHINGS, Esq.

(*Concluded from page* 161.)

TAKING the other and coarser constituents of such slates as are not wholly made up of the fine "base,"—the constituents which may be spoken of as "porphyritic,"—the *lapilli* vary very greatly in number and distinctness. In a large part of the roofing-slates they are either no longer discernible at all or are so exceedingly faded and blurred as to be just barely recognizable, often as patches altered to chlorite, or chlorite and calcite, in which the felspar-laths of the original andesitic ground-mass may still be seen comparatively little altered. In cases where there is reason to suppose that the lapilli were largely of more *basic* nature, this almost complete alteration of them is observed, as might naturally be expected.

In other cases the crushing and rolling-out of the rock has sufficed to obliterate all traces of original fragments of whatever sort. On the other hand, there are many slates in which lapilli, in great abundance, are still so perfectly preserved as to exceed in freshness most of the andesites, etc., which can be collected *in situ*. Even in some cases where the slates are most highly cleaved, and the "base" and some of the other constituents, as chlorite and calcite, are drawn into streaks often flowing round the still angular lapilli, these latter have almost wholly escaped mechanical damage. In these cases of strikingly good preservation basic lapilli are absent. The slates from Mosedale quarry have already been mentioned as offering beautiful examples of well-preserved lapilli, and equally good ones are seen at other places.

It is to be noted that though rhyolite is exposed in comparatively few localities in the district, it is more or less represented in almost every specimen of slate in which the lapilli are still distinct. This frequent occurrence of rhyolite in the fragmental rocks of the Lake District has been noticed also by Harker and Marr (On the Shap Granite, etc., Quart. Journ. Geol. Soc. vol. xlvii. 1891).

In addition to volcanic lapilli, many of the slates and tuffs show also the presence of fragments of sedimentary rocks, presumably broken through and ejected by the explosive eruptions. I have formerly recorded (GEOL. MAG. 1891, p. 462) the occurrence of such a mixed volcanic and sedimentary material in a tuff at Falcon Crag. It may be observed again, though in less marked degree, in rocks from Honister Crag, both roofing-slates and coarser tuffs and breccias, in which fragments of grits and gritty slates occur; and in material from several other localities careful search shows that fragments of ordinary sedimentary slates are present, recognizable, among other things, by the rutile-needles contained in them. In many cases these fragments are crushed and drawn out so as to be almost incorporated beyond recognition with the volcanic material, and it is most likely that, as might be expected, a large proportion of the ashes and tuffs of the district contain more or less of the sedimentary strata underlying them.

Angular clastic grains of quartz, some of good size, are also tolerably frequent, suggesting a derivation from some coarse-grained acid rock, probably granite.

None of the finer-grained slates, so far as my observations go, contain any trace of augite or other ferro-magnesian mineral. These are now represented entirely by chlorite, calcite, and some epidote. Chlorite is always present in large quantity in the coarser slates, as patches and rolled-out streaks, as well as in the minutely-felted form in the base. Calcite is exceedingly abundant, disseminated as small grains down to fine dust, or as larger grains and crystals. These frequently contain fluid-cavities with bubbles, showing the conditions of pressure, etc., under which this calcite was deposited. In many slates the calcite is so plentiful that it very nearly obliterates everything else except the chlorite, the rolled-out mixture of the two appearing at first sight to make up nearly the entire rock.

It is interesting to note that though the mineral changes which have taken place in the finely-powdered ash-material of these slates are in a most important point similar to those which have occurred in the deposits to which we owe our fireclays and shales and most of our sedimentary slates, inasmuch as a very large amount of new mica has been formed, yet in the matter of the titanic acid contained in the material acted upon the result is very different.

It is beyond question that the volcanic rocks of the Lake District contain a quite considerable amount of titanic acid, though it has not been determined in the analyses made.[1]

Probably a portion was combined in the form of sphene, but most likely the greater part was contained in the augitic minerals. In the weathered and much altered andesites as we now have them, *secondary* sphene is one of the most constant constituents, in granular form and also as little clusters and groups of crystals, often evenly disseminated throughout the rock. This sphene has probably been mainly formed during the decay of the augites and the basic portion of the ground-masses. At Shap, under the influence of contact-action, the sphene of the andesites and ashes appears to have been re-dissolved and re-deposited, one of the most striking features of the altered rocks being the considerable number of large grains of deep-coloured, very dichroic sphene which have been formed, wholly different from anything seen in the rocks at a distance from the contact. Sometimes these large grains of sphene occur in cavities in such relationship to quartz and other infiltrated matter as to leave no room for doubt as to the manner of their deposition.

Notwithstanding this considerable amount of titanic acid, however, the slates resulting from the chemical and mechanical alteration of the andesitic ashes do not ever show the rutile-needles so universally characteristic of the sedimentary clays and slates. From a considerable observation of these rocks from all over the district I am able to state that rutile in that form is never noticed in them, except in those cases in which it is explained by included sedimentary matter originally containing it. To the best of my belief, based on much study of this special point, it may be pretty safely said that rutile in the form we know as "slate-needles,"—a form so very characteristic and always recognizable,—occurs only as the result of decomposition, under certain conditions, of deposits partially consisting of biotite. As I have noted in a former paper (GEOL.

---

[1] Even now that the general presence of titanic acid in rocks is more fully known than formerly, it is very rarely determined by analysts. This arises to some extent from the fact that its non-determination does not affect the total addition of the analysis, as in the ordinary course of the estimations it is weighed partly with the silica and partly with some of the bases. But the non-determination is more largely due to the fact that the exact quantitative serparation of titanic acid is a very tedious and difficult operation.

In the "American Journal of Science" for December, 1891, is an interesting paper by Mr. F. P. Dunnington, "On the Distribution of Titanic Oxide upon the Surface of the Earth," in which he gives the results of 72 determinations on soils from various parts of the world, as well as on a few rocks. The universal diffusion of this oxide in appreciable quantity is fully demonstrated. These many determinations were not made by Mr. Dunnington in the ordinary tedious gravimetric manner, but by a rapid calorimetric process which is described in the paper. It is to be supposed that this method has been fully checked and proved to be reliable. That being so, the determination of titanic acid in our rocks and minerals ought to become the rule instead of the exception, since an easy and rapid method is available for it.

MAG. 1891, p. 537), biotite appears to be practically absent from the rocks of the Borrowdale series.[1]

The titanic acid in these slates takes other forms. It largely occurs, as in the altered andesites, as disseminated granules and small crystals of secondary sphene. Slates showing this, to the exclusion of any other form of occurrence, are exemplified in the quarries at the top of Kentmere Valley, and on the other side of the same ridge in Troutbeck Valley.

Rutile occurs, though on the whole sparingly, in the form of blunt crystals and grains lining cavities, the central parts of such cavities being usually filled in with quartz, or calcite, or both.

Another and more widely-spread form of occurrence is as anatase in small double pyramids, with or without the prism-band, exactly as in the altered Coniston Flags at Shap.[2] These anatase crystals were first noticed in a slate from Honister Crag, and some difficulty was at first experienced in accepting the true nature of their origin. I was disposed to regard them as having been introduced in metamorphosed sedimentary fragments, as in the case of the tuff at Falcon Crag, and to suppose that the crystals had remained distinct after the other material of the fragments had been completely obliterated and absorbed into the rest of the slate. But longer observation of this particular occurrence, and of numerous others subsequently found, quite dispelled that idea. There is no doubt that the solutions which have permeated the ash-beds, and which have acted under high pressure (as witnessed by the bubbles in the calcite) and probably high temperature also, have dissolved titanic acid and allowed it to re-crystallize (according to differences of conditions we are not able to specify), either as anatase, more sparingly as rutile deposited in cavities, or in combination with silica and lime as sphene. The anatase occurs mainly as clusters in patches of chlorite. With the perfect crystals are often large numbers of grains not showing definite forms, but apparently deposited at the same time. The mineral occurs also in secondary quartz-grains which are abundant in some of these rocks; in calcite, though rarely, and now and then in felspar-substance. In some cases cavities are seen lined with rutile, and filled in with quartz in which are perfect little crystals of anatase; so that between the time of deposit of the rutile on the sides of the cavity and the final in-filling with quartz a change of conditions as to nature or temperature of solutions, or both, had taken place, which altered the crystal-forms of the titanic acid being deposited.

It may be noted that in slates which show very much sphene anatase does not usually occur. Otherwise a large number of the slates contain it in varying amount, sometimes very scarce and sometimes in crystals so small as to require very careful search for its detection, but at other times very abundantly and of larger sizes, ranging up to $\frac{1}{3000}$th of an inch in length.

---

[1] It is also to be remarked that the small crystals of tourmaline, so usual in clays, shales, and slates, are never seen in these ashes.

[2] Since the above was in print, I have had the opportunity of examining some of these minute anatase crystals by means of a $\frac{1}{12}$ inch oil-immersion objective. This has enabled me to see them very much better than I ever did before, and to ascertain that I was mistaken in stating that the prism-band is present on some of them. The apparent band disappears when the crystals are seen under the great magnification, together with fine definition, which the use of this objective gives us,

The various experiments on record as to the artificial formation of crystallized titanic acid by sublimation show that variations of temperature cause variations in the resultant crystal-form;—rutile, anatase or brookite being obtained at different parts of the apparatus. Similarly the three minerals may be obtained by fusion of titanic acid in different solvents. The same no doubt applies as regards solutions of titanic acid in liquids, and its crystallization out of them under various conditions; but there appear to be very few experimental data as to this, and we can only speculate as to the exact nature of the solutions which have acted in these rocks. It is stated by Doelter (Allgemeine Chemische Mineralogie, p. 155) that by means of water containing sodium fluoride he succeeded in re-crystallizing titanic acid in the form of rutile. He also gives interesting figures (*loc. cit.* p. 189) showing a very noticeable solubility of titanic acid (powdered rutile) even in pure water, in sealed tubes at 80° C. From various considerations it is probable that the solutions acting in these rocks were largely charged with alkaline silicate; a solution of alkaline titanate was probably formed at the same time, out of which carbonic acid would liberate titanic acid. It seems likely that so far as concerns temperature, pressure, etc., the conditions existing in many of these beds of the Borrowdale Series when the main changes took place, did not materially differ from those under which the Coniston Flags at Shap were metamorphosed near the granite, exactly similar solution of the titanic acid and re-crystallization as anatase having taken place in some of these flags (Harker and Marr, Quart. Journ. Geol. Soc. vol. xlvii. 1891; also Hutchings, GEOL. MAG. 1891, p. 462).

Among the various changes which have taken place in the minerals of these rocks, those which concern the felspars have the greatest interest. The points involved are, of course, the same whether we study the felspars in the slates and other detrital rocks or in the altered andesites, and what follows may be taken as applying equally to both classes.

The normal decomposition of the felspars of these rocks does not seem, so far as can be made out, to lead to kaolinization.[1] The three main types of decay, sometimes singly, sometimes together, give rise respectively to white mica, a very pale chloritic mineral, and calcite. The formation of white mica is very usual all over the district. In many andesites and ashes the felspars, while retaining their original outlines perfectly sharply, are internally quite full of mica flakes, often of good size, hardly ever showing any sort of orientation to the crystal-planes of the containing crystal, but occurring equally in all directions and often as tangled clusters of flakes at all azimuths. This lack of orientation of the mica formed in felspars appears to be not unusual. I have noticed it in other rocks; and it is pointed out by Rosenbusch (Microscop. Physiog. der Gesteine, p. 23).

---

[1] It is usually considered to be difficult, and indeed often impossible, to distinguish

Among the mica in the larger crystals may often be seen quartz, and usually more or less of perfectly glassy clear felspar.

Where the alteration has given rise to the pale chloritic mineral, a more definite orientation appears to largely prevail. This chlorite is very faintly dichroic, and polarizes in thin sections in tints up to yellowish-white of the first order.

Calcite frequently accompanies the other two products, and often occurs by itself, in all stages up to the total replacement of felspar crystals by pseudomorphs in calcite.

Mr. Alfred Harker, in a petrological appendix to a paper by Prof. Nicholson and Mr. Marr ("The Cross Fell Inlier," Quart. Journ. Geol. Soc. vol. xlvii. pp. 512–525), alludes to the fact that in some of the rocks in question the evidence goes to show that a large part of the felspars are "regenerated," and have a secondary twinning due to crushing. He specially alludes to a rock from Wythwaite Top, giving details as to his observations on the porphyritic felspars contained in it and their alterations (p. 515).

Similar occurrences may be noticed more or less all over the Lake District, and these rocks offer a splendid field for the investigation of the many questions, as yet only partially understood, as to the re-generation and re-crystallization of felspars, with or without secondary twinning, due to crushing and shearing. Specimens may be obtained at many points from ashes (fine tuffs and slates), and often from altered lavas, in which the usual turbid felspars full of mica, chlorite, or calcite, with the twinning nearly or wholly obliterated, are replaced by more or less glassy clear crystals often beautifully twinned. These are not crystals and fragments which have escaped decay, but are obviously felspars which are re-formed *in situ*,—often, apparently, completely re-crystallized and re-twinned. The rocks in which these occur all give full evidence of great stresses, and the felspars themselves are often bent, broken, and re-cemented with chlorite in a most complex manner.

In the slates of Honister Crag, and many other quarries, any number of bits may be seen, as clear as fragments of window-glass except for a little brownish dust in some cases, a large proportion of such bits showing beautiful twinning in polarized light. Many other bits, equally clear and glassy, show no twinning whatever, nor any cleavage, and are only to be discriminated from quartz by

microscopically between kaoline and muscovite as alteration-products in decomposing felspars. Rosenbusch, for instance, points this out very emphatically (Physiographie der Mineralien, pp. 516, 561). The flaky alteration-product in felspars is certainly sometimes so minute, and occurs in such an indistinct manner, that decision as to its exact character is very uncertain or impracticable. But as soon as the flakes are larger and more distinct (and this is often eminently the case in the rocks now under consideration), I venture to think that the identification of the mica can be safely made. The bi-refraction of kaolinite is high, but so far as my observations go it is *very distinctly* less than that of muscovite, observing transverse sections in each case. Then again, edge-sections of the mica extinguish parallel, while edge-sections of kaolinite give such very decided angles that no confusion of the two minerals appears possible. I have used for these comparisons the well-known kaolinite crystals from Anglesey, and also those which occur abundantly (though of smaller size) in the interstices of many coarse sandstones and grits of the Coal-measures.

optic tests in convergent light; and in some cases, in tuffs, large decayed felspar-fragments have been re-generated into mosaics of clear grains in the well-known manner.

What these felspars now are it does not seem possible to decide on optic tests alone, in thin sections. The multiple twinning in most cases points to plagioclase, and extinctions appear to indicate albite, oligoclase, and andesine as probably the varieties. But nothing short of a laborious isolation and analysis of specimens could give a safe decision. It appears to be usually considered that albite and andesine are the varieties chiefly produced by the dynamic re-generation of decayed original felspars.

In the paper above referred to Mr. Harker brings forward the question of the formation of new felspar by deposit in vesicles, and describes a case of such an occurrence in one of the Cross Fell rocks, the felspar in question being well-twinned plagioclase with extinction-angles pointing to albite or andesine.

According to my own observations, this mode of occurrence is not by any means very rare, and I can point to several cases of cavities in these rocks which are lined with chlorite, etc., and contain felspar in such a manner as to apparently forbid any other explanation than that the mineral has been crystallized from infiltrations into the cavities. The question first attracted my attention in connexion with the altered rocks round the Shap granite. Messrs. Harker and Marr allude to felspars formed in vesicles by the metamorphism of their contents. They refer to one particular slide in which this is observed, but state that it does not seem to have commonly occurred. Whether it be due to contact-action or not, my own impression is that it is very usual at some points round the granite, as I have several slides in which well-defined felspar, often in good large individuals, frequently occurs in vesicles with quartz, biotite, hornblende, etc. It is mostly plagioclase, but I have one slide, which I have submitted to Mr. Harker, in which occur grains of what seems to be orthoclase, perfectly clear, beautifully cleaved, and extinguishing quite parallel to the cleavages. One such grain is over ¼ inch in diameter filling an irregular cavity, which may have been a vesicle, but seems more likely to have been due to the removal of some former mineral. I at first attributed these large grains, as also the smaller plagioclase in vesicles, to the action of the granite, and this may be correct, but it is not necessarily so, as later observations showed me that all these occurrences are paralleled in rocks far outside the contact-zone. Cavities with plagioclase, and apparently also orthoclase, occur not rarely in the coarser slates at Mosedale, for instance; and the grains of well-cleaved felspar, apparently orthoclase, are seen again in sections of the andesite of Harter Fell, Mardale, where the mineral occurs in a precisely similar manner as large, irregular, perfectly glassy-clear, untwinned grains in a rock whose original felspars are all sharply and definitely bounded, and are now exceedingly turbid.

I look upon all these cases as due to causes wholly distinct from the dynamic regeneration of decayed felspars, and as explained by simple deposit from solutions, exactly as albite, orthoclase, etc., are known to be deposited on a larger scale in veins and cavities.

There are also, so far as I can make out, what certainly appear to be orthoclase crystals in some of these rocks, which seem to require another explanation. They are not in cavities, and for various reasons they do not appear to be original crystals, but to be "regenerated" ike so many of the plagioclase crystals. I have come, after much consideration of them, to regard them as not improbably pseudomorphs after former plagioclase, on the theory (or hypothesis) that olutions containing silicate of potash have acted upon these former elspars, removing soda and lime and replacing them with potash, One such crystal observed, which optically fully corresponds to orthoclase, contains a cavity lined with deposited rutile, evidently ormed at the time that solutions were strongly acting on the original crystal.

In some of the normal andesites the much-altered felspars full of mica, chlorite or calcite, show in among these secondary products, as before stated, more or less of clear glassy material. It is not an uncommon thing to see this glassy felspar in considerable quantity n long streaks and patches, and where the outline of the crystal is ully preserved, as often is the case, to see that this felspar is optically uniform all over the crystal, is quite free from twinning and extinguishes perfectly parallel to the crystal-boundaries, or at angles which point to orthoclase. In some of the rocks crystals are requent which are wholly glassy clear, save for trifling inclusions, and behave as above described, occurring together with plagioclase which is obviously regenerated.

Such changes as I suggest may have taken place do not appear at all unlikely under the conditions which we have reason to nfer obtained during the alterations these rocks have undergone, and there appears to be good independent evidence that they have been observed and chemically proved elsewhere. A leading authority n this class of investigation appears to be Lemberg. I have not at present an opportunity of consulting his original papers, but in Roth (Chemische Geologie, vol. i.) among other abstracts from and eferences to Lemberg's work are certain facts which bear very directly on the point in questions.

Thus, Lemberg analyzed oligoclase from the tourmaline-granite of Monte Mulatta, and its green alteration-products in four examples, , *b*, *c*, *d*. The alkalies were as follows:—

	Original Oligoclase.	*a.*	*b.*	*c.*	*d.*
Soda =	7·26 per cent.	2·14 p.c.	0·70 p.c.	2·23 p.c.	0·84 p.c.
Potash =	2·10 ,,	3·00 ,,	5·28 ,,	4·54 ,,	7·43 ,,

water is also taken up at the same time.

Other analyses of Lemberg's are also given, showing similar hanges in oligoclase, some chloritic mineral being apparently formed, with a simultaneous removal of soda and increase of potash. An nalysis of labradorite is also given, together with that of its alteraion-product, showing—

	Original labradorite.	*Alteration-product.*
Soda ...	5·43 per cent.	0·88 per cent.
Potash...	0·92 „	8·51 „

and in another still more extreme case the alteration-product contained Soda = 0·17 p.c.; Potash = 9·71 p.c.

From this latter alteration-product acid extracted 37·61 p.c. of a silicate of magnesia, alumina and iron oxides,—evidently a chloritic substance. The residue left after this extraction contained very nearly all the potash, "and corresponded in composition to orthoclase." These alterations appear to be exactly cases of what I suppose to have taken place in some of the andesites.

A chloritic mineral is formed, with a simultaneous more or less extensive *chemical* alteration of the soda-lime felspar, tending to convert it into orthoclase. In these Lake District rocks powerful dynamic action, following on the chemical change, may be supposed to have completed the work in *re-crystallizing* the felspar-substance. It will not affect the question, whether chlorite, mica or calcite is formed during the chemical stages of these processes.

In commenting on the above results of Lemberg, Roth points out that it is not indicated from what source the potash was supplied which was taken up during the changes of the felspars. In the case of the rocks we are considering there is no difficulty as to such source. I have shown how frequently white mica is formed in the alteration of some of the felspars of these rocks, and how specially and very largely this is the case in the beds of fine ash and tuff. In these ash-beds the finely-pulverized material has undergone these alterations as a *whole*, including the portion which in the massive andesites is consolidated as ground-mass, considerably richer in potash than the rest of the rock, but undergoing these changes, as a rule, in a very much less degree.

These changes, as we have seen, entail a considerable liberation of potash as soluble silicate, and we may be sure that during their progress all these rocks, as a whole, were permeated by solutions containing that salt, and also carbonate of potash. These solutions would play an important part in further changes, and acting upon soda-lime felspars (themselves containing more or less of potash) already in course of decay, would easily and naturally bring about the alterations supposed. No doubt similar explanations would apply in the cases proved by Lemberg.

Lemberg was apparently able to isolate the special felspars, the alterations of which he wished to study. Such isolation is, unfortunately, not possible in the case of the rocks to which I refer. The felspars are so small that the picking-out of them is not practicable, and their isolation from the crushed rock by means of dense solutions is a tedious and difficult matter. Also it is not possible in this manner to separate the different *varieties* of felspar one from the other, as even in the most favourable of the occurrences examined, the included secondary minerals, though small in amount, suffice to completely counteract the normal differences of specific gravity.

Under these circumstances it has not been possible to obtain any very effective chemical evidence on the point in question.

The most favourable rock in my possession is an andesite from a point not far from Ulleswater, on the road to Matterdale. Its ground-mass is fine-grained, and appears to have been originally "hyalo-pilitic." There are numerous well-defined pseudomorphs of chlorite after augite. The porphyritic felspars are numerous, but small, ranging from about $\frac{1}{20}$th of an inch in length as maximum. They are largely more or less glassy clear, and contain comparatively little of secondary minerals;—chlorite, calcite, a little epidote, with but little mica in this case.

A good many of them show the appearances above stated which lead me to suppose they are perhaps orthoclase. The rest are plagioclase, of which, as usual, it is not possible to safely determine the variety, though oligoclase appears to be present. A large piece of this rock was pulverized and reduced to uniform very small grains by means of wire gauzes of suitable mesh. The powder was subjected to repeated separations in liquids of diminishing specific gravities, the lighter portions being successively concentrated, a final separation being made in a liquid in which a fragment of pure labradorite just remained suspended. In this manner, with plenty of time and patience, it was possible, in spite of the unfavourable nature of the rock and of the smallness of the grains, to separate from a large bulk a small quantity of material which proved to be felspar, free from ground-mass, and contaminated only by small amounts of chlorite and calcite. This was finely powdered, digested a short time in hydrochloric acid of moderate strength (sufficient to decompose chlorite), and finally in dilute potash liquor to remove separated silica. The residue, well washed and dried, was practically pure felspar.

A sample of the bulk of the powdered rock contained: Silica, 62·43 per cent.; Soda, 4·13 per cent.; Potash, 2·28 per cent., as kindly determined for me by Dr. J. B. Cohen. This does not differ appreciably from the average run of analyses of local andesites, though the potash is perhaps a trifle higher than usual.

The isolated felspar-substance was analyzed by Mr. Paterson and contains Soda 8·52 p.c.; Potash 4·1 p.c.

Having regard to the facts that in all rocks of this class the potash concentrates in the ground-mass, and that the average of the entire rock is here only 2·28 p.c., we should not expect to find anything like so much as 4 p.c. potash in the porphyritic felspars. Its presence in them in this amount would seem to justify the inference that some of them are specially rich in it, and that, indeed, some potash-felspar is probably present together with the plagioclase.

In some of these rocks, again, there appear to be examples of those very interesting phenomena which have been so beautifully described and illustrated by Prof. Judd in his paper, "On the Growth of Crystals in Igneous Rocks after their Consolidation" (Q.J.G.S. vol. xlv. 1889).

They are not so large nor so striking as the instances quoted and figured in that paper, but there are in some specimens crystals which show all the principal appearances enumerated by Professor Judd, and which cannot, I think, be explained satisfactorily in any other manner than that which he has given us.

NOTICES OF MEMOIRS.

I.—The Oolitic Rocks at Stowe-nine-Churches, Northamptonshire. By Beeby Thompson, F.G.S., etc. (Journ. Northamptonshire Nat. Hist. Soc. Vol. VI.)

IN this paper Mr. Thompson describes a section of especial interest, as it shows the sequence of beds from the Northampton Sands to the Oxford Clay. The tract near Stowe, situated about seven miles west of Northampton, is a faulted one, and to this cause is due the preservation of the Great Oolite and higher beds, which elsewhere in the immediate neighbourhood have been removed by denudation. The beds have been quarried chiefly to supply limestone for fluxing purposes to the Heyford furnaces near by.

The chief new points in this paper concern the identification of the small area of beds overlying the Great Oolite, as these were not indicated on the Geological Survey Map. The highest bed beneath the Drift soil is a blue clay grouped as Oxford Clay. There can be little doubt that this represents the clay usually found between the Cornbrash and Kellaways rock, and sometimes designated the Kellaways Clay.

The Cornbrash contains some of the usual fossils met with in the formation, and it rests on a series of beds grouped with the Forest Marble and Great Oolite Clay. The presence of beds of flaggy limestone resembling varieties of Forest Marble is of interest, as they are only occasionally met with in the country to the north-east of Bicester, in Oxfordshire.

The Great Oolite Clay is not, as Mr. Thompson thinks, the bed to which the term 'Cornbrash Clay' has been applied; that Clay, where it occurs, overlies Cornbrash rock, partly replaces it, and passes up into the Kellaways Clay.

The Great Oolite Limestone and lower beds are described by Mr. Thompson, and lists of fossils are given from these as well as from the higher strata. A photographic plate and a plate of diagram-sections illustrate the paper. H. B. W.

II.—Notes on the Fossil Aphidæ and Tettigidæ.

I. IN Mr. G. B. Buckton's late Monographs on British *Aphides* and *Cicadæ*, are thoughtful remarks on the known fossil forms of these two great families of Insects, and we here reproduce them as interesting to our readers,—premising that these Insects belong to the *Homoptera*, whose zoological relationship is as follows—

Hemiptera: A. Homoptera: *Aphides*, *Coccidæ*, *Cicadæ*, *Fulgoridæ*, etc.

B. **Heteroptera**: *Hydrocorinæ* (Water-bugs), *Geocorisa* (Land-bugs).

II. In the "Monograph of the British *Aphides*," vol. iv. 1883, Ray Society, at pages 144—178, Mr. Buckton gives a sketch of the geological occurrences of Insects in general, and of the *Aphidinæ* in particular, and finds that the *Hemiptera* are nearly as ancient as the *Coleoptera*, and apparently preceded the *Diptera*, *Hymenoptera*, and *Lepidoptera*. The earliest known *Aphides* have been recognized by Westwood, as collected by Brodie in the Purbeck beds of Wilts and Dorset. In the Eocene Tertiaries of Europe Aphis occurs fossil; and even if not present, its enemies who fed on it (*Syrphidæ* and *Coccinellidæ*) and others (Ants) that sought its honey-dew, have left their remains. At Radaboj in Croatia, and Œningen in the valley of the Rhine, *Aphides* are present in Miocene strata. Indeed in the Swiss Miocene 136 species are known. The *Aphididæ* of North America have been described by Scudder from the White-River District in Utah, and the Green-River-Station in Wyoming; also from the Florissant-Lake strata in Colorado, the last giving eight species of *Aphidinæ*. The many species of *Aphides* found in Amber have occupied the author's attention (pages 160–168). He gives a lucid account of what has been published about Amber and its origin; and indeed he also alludes to what geologists have determined about the Tertiary and other strata in which *Aphides* occur, and especially about the flora represented by the plant-remains accompanying these Insects at the several localities.

Plate cxxxi. contains figures (after Berendt) of Germar and Berendt's species from Amber; namely, three of *Aphis* (?) and two of *Lachnus* (?), carefully described in the text.

In plate cxxxii. Mr. Buckton figures, from earlier drawings, one *Aphis* (?) from the Purbeck; one from the Tertiary of Amberieux (Ain); one *Aphioides* from Amber; four of *Aphis* (?) and three of *Lachnus* (?) from Radaboj; and a *Pemphigus* (?) from Œningen.

Some fossil *Aphides* from Florissant, Colorado, are figured (after Scudder) in plate cxxxiii. Five new genera are described by Buckton, at pages 176–178, as *Siphonophoroides* (2 spp.), *Archilachnus*, *Anconatus*, *Schizoneuroides*, and *Pterostigma* (1 sp. each).

III. In Mr. G. B. Buckton's "Monograph of the British *Cicadæ* or *Tettigidæ*," 1891, Macmillan & Co., London and New York, some fossil forms are referred to in vol. ii. at pages 164–184.

After some remarks on the bibliography of Fossil Insects, their occurrence in freshwater rather than in marine deposits, their local abundance in isolated groups or masses, and the possible conditions of preservation, the author observes that the *Hemiptera* lived in Carboniferous times in the American and British areas, contemporaneously with the gigantic *Dycteoptera* (Cockroaches) and *Coleoptera* (*Buprestidæ*) which crawled amongst the Equisetums and Tree-ferns of that early period. A few Hemipterous remains are described by Scudder from beds below the Lias or Rhætic in Colorado; and some specimens from the Rhætic at Schönen in Sweden have been referred to *Cimex* and *Cicada*. From the Rhætic (?)

of Schambelen (Aargau), Switzerland, O. Heer enumerates 143 fossil Insects, of which 12 are *Hemiptera*. The Jurassic *Palæontina oolitica*, from Stonesfield, was referred by Mr. A. G. Butler to *Lepidoptera*, but others believe it to belong to *Cicadæ*. In some of the Purbeck beds of Wilts and Dorset Insects are known to be abundant, as shown especially by Brodie and Westwood, in 1844 and 1854. Of the *Tettigidæ*, Prof. Westwood determined remains of a small *Cicadellina*, and of a *Cercopis* and *Bythoscopus*. Though Insect remains are plentiful in many Eocene Tertiary beds, only in the gypsum of Aix-en-Provence have discoveries of *Cercopidæ*, *Cixiidæ*, and *Cicadellinæ* been made.

To the Oligocene period Mr. Scudder refers the remarkable fresh-water insectiferous deposits of Colorado. which form part of islets in the Florissant Lake. The fauna and flora agree partly with those of Œningen near Schaffhausen, and Radaboj in Croatia, which belong to the Miocene. In British Columbia, Dr. G. M. Dawson discovered some lacustrine insect-bearing strata, believed also to be Oligocene in age; and they have yielded to Mr. Scudder 19 *Hemiptera*, of which only two are truly Hemipterous; whilst there are eleven Homopterous *Cercopidæ*, three *Fulgoridæ*, and two *Aphidæ*. All are of larger size than the usual Tertiary Insects. Of all the American fossil insects, from areas far apart, 612 species have been described, of which the *Hemiptera* form the large proportion of 266 species, and Mr. Scudder regards the known European species of *Hemiptera* as numbering 218.

The Miocene of Switzerland has yielded multitudes of fossil Insects, mostly discovered and described by O. Heer. Among them are 636 Hemipterous species; and by far the majority of these are larval forms. The presence of at least one *Cicada*, and the numerical preponderance of *Reduviidæ*, *Scutata*, and *Coreodeæ*, also the occurrence of several fine *Cercopidæ* and large Water-bugs, give good evidence that a warmer climate (especially milder winters) then prevailed over Central Europe than now. O. Heer thought also that as these insects undergo an incomplete metamorphosis, and are more or less active in their pupal conditions, they were better suited to regions not subjected to the rigours of long cold winters.

From the Miocene of Greenland and Spitzbergen examples of *Cercopis* and *Pentatoma* have been obtained. From New South Wales Mr. R. Etheridge, jun., has described (1890) the fossil *Cicada Lowei*.

The Amber of the Baltic and elsewhere (pp. 171–173; see also "Monogr. Aphides," pp. 160–165) contains many specimens of *Tettigidæ*, of these Mr. Buckton's Plate G illustrates two specimens of *Typhlocyba*, two (?) of *Jassus*, one of *Tettigonia*, and four of *Cixius*; also one *Cicada* in copal-resin from Zanzibar.

Of other fossil *Tettigidæ*, Mr. Buckton's Plate F illustrates Butler's *Palæontina oolitica* (elytron); two species of *Cicadellium* and one of *Cercopidium*, from the Purbecks; one *Cicada* and two species of *Cercopodium* from the Swiss Miocene; one *Agallia*, one *Petrolystra*, and one *Palæcphora*, from the Oligocene of Colorado; also

Thammotettix, a *Dawsonites*, and a *Stenecphora* from the Tertiary British Columbia.

At pages 178–181 Mr. Buckton refers to geological speculations to the changes of land and climate affecting Insect-life in late rtiary and Quaternary times; also to possibilities of development l of degeneration among Insect forms in geologic times, and he itates to offer any outline of the phylogenetic descent of the *moptera* in particular. T. R. J.

REVIEWS.

-The Cause of an Ice Age. By Sir Robert Ball, LL.D., F.R.S., Royal Astronomer of Ireland. Pp. 180. (Kegan Paul, Trench, Trübner & Co. 1891.)

HIS little book contains a very clear and agreeably written exposition of the commonly received Astronomical theory of Glacial iods. But it goes further than that, because it offers an explana- of a difference of the mean temperatures of either hemisphere ing the summer and winter seasons, reckoning from equinox quinox, which has not hitherto been taken due account of in mating the effects of the earth's position with reference to the The author proves, by a short calculation given in an Appendix, owing to the obliquity of the ecliptic the quantity of heat, ived from the sun upon one hemisphere during its summer, s to the quantity received during its winter the invariable pro- ion of 63 to 37. This will be the case always, whatever be position of the equinoctial line with respect to the major axis of orbit, and whatever be the eccentricity of the orbit. He points that, in consequence of an inadvertence in a statement in schel's Outlines of Astronomy, the proportion has hitherto been rded as one of equality; and it is obvious how great a difference consideration will make in estimating climatic effects.

he greatest eccentricity which the earth's orbit can have is about . When with this eccentricity winter in the northern hemi- re occurs in aphelion, taking the mean daily heat for the whole received by that hemisphere, as unity, the mean daily heat ved by it in a short summer of 166 days will be represented ·38; and the mean daily heat received in its long winter of 199 will be only 0·68. This, the author says, will produce a severe al epoch, when the summers will be short and very hot, and winters long and very cold. While the eccentricity remains the (for it changes very slowly) when the axis of the earth is next ed round by precession until the winter occurs in perihelion, the daily heat received in a long summer of 199 days will be 1·16, in a short winter of 166 days will be 0·81. This he believes produce an interglacial period—interglacial because two or such reverses may occur before the eccentricity is sensibly ed. It must be remembered that the unit of heat here used is y large one, being that which raises the mean temperature of the hemisphere from that of space to that which it actually has, which rise may be perhaps measured by 300° F.; so that 0·1 may represent a difference of 30° F. The above may suffice to point out the importance of the work in regard to the astronomical theory of the Glacial epoch. It adds fresh force to Dr. Croll's hypothesis.

There appears to be a slip at p. 95, where it is said that, "with the present eccentricity of the Earth's orbit, the greatest possible difference between summer and winter would amount to 33 days, etc." Such a difference could only occur when the eccentricity had its highest value of 0·07, whereas at present its value is only about 0·017.

Sir Robert Ball does not venture to say when the last ice age took place, nor when the next may be expected; but only that, when they do occur, they will be separated by 21,000 years. with interglacial periods intervening. Prof. Darwin, in his notice of this book in "Nature," Jan. 28, regrets this reticence, and inquires whether Leverrier's formulæ, which Croll used, may not be relied on to give an approximation to the value of the eccentricity for about 100,000 years in the past. Croll constructed an elaborate chart, showing the eccentricity for three millions of years in the past, and one million in the future. Considering the enormous labour with slight mathematical powers at his disposal, it makes one sad to think that much of this labour was not more profitable; but if the formulæ can be depended on for 200,000 years in the past, an eccentricity of 0·0569 occurred at about that date, which, on his hypothesis, might have been sufficient to bring about the Glacial epoch.[1]

Looked at from the geologist's point of view, this book seems rather too triumphant. The author appears to think there are fewer difficulties remaining than the geologist would admit. For instance, he attributes the climate of what are now Arctic regions, at the time when a luxuriant flora flourished there, to an interglacial period. But, seeing that a single night of severe frost will kill a fig-tree, it is hardly credible that, even with a short winter and a nearer sun, frosts should never have occurred at a place within the Arctic circle, which would have been fatal to such vegetation.[2] Again, he points out that the astronomical theory necessitates the recurrence of glacial epochs through all past geological time, and to explain away the objection that glacial deposits and scratched stones are not to be met with to testify to their frequent recurrence, he refers to the unconsolidated and perishable nature of such deposits. But Till and Boulder-clay are less destructible than many clays, and other unconsolidated deposits, which have been buried again and again under newer strata without being disturbed; and they occur in India possibly in Palæozoic strata.[3]

Other points will occur to the geologist where difficulties appear to be passed over. But although a few passages betray that "The

---

[1] See a paper on the Ages of the Trail and Warp by the writer, Geol. Mag. Vol. IV. pp. 193–199, 1867.

[2] See discussion on Prof. O. Heer's paper on fossil plants from North Grinnell Land; Quart. Journ. Geol. Soc. 1878, vol. 34, p. 70.

[3] Quart. Journ. Geol. Soc. 1878, vol. 34, p. 375.

Cause of an Ice Age" is not the production of a professed brother of the hammer, nevertherless it will well repay perusal, and all must acknowledge that a valuable contribution has been made by a distinguished ally, bearing upon one of the most difficult problems of our science. O. FISHER.

II.—PALÆOZOIC FISHES.

1. ON THE CHARACTERS OF SOME PALÆOZOIC FISHES. By E. D. COPE. Proc. United States National Museum, Vol. XIV. (1891), pp. 447–463, Pls. XXVIII.–XXXIII.
2. UEBER *PTERICHTHYS*. By J. VICTOR ROHON. Verhandl. Russ. Kais. Mineral. Ges. St. Petersburg, Vol. XXVIII. (1891), pp. [1–25 reprint], Pl. VII.

OUR knowledge of the Palæozoic Fishes is still progressing rapidly both in Europe and America, and we have lately received the two papers on this subject quoted above. Prof. Cope's communication is divided into seven parts, and deals with several important types; Dr. Rohon's work is chiefly an examination of the histological structure of the shield of *Pterichthys*.

The first fossils noticed by Prof. Cope are referable to Elasmobranchii. A detatched tooth from the supposed Permian of eastern Nebraska, named *Styptobasis Knightiana*, is very remarkable on account of the small size of its base of insertion; we should, indeed, prefer to have some information as to its microscopical structure before accepting the fossil definitely as an Elasmobranch tooth. A typical spine of *Ctenacanthus* (*C. amblyxiphias*, sp. nov.) from the Permian of Texas is a noteworthy discovery; and the first truly hybodont fin-spine met with in the New World (*Hybodus regularis*, sp. nov.) is also of much interest, though it is not Palæozoic, being from the supposed Trias of Baylor County, Texas.

The Elasmobranch fragments are only of limited importance, but Prof. Cope's description of the cranium of *Macropetalichthys*—one of the most remarkable and least understood American Arthrodira or "Placoderms"—tends towards a considerable advance in our knowledge of the great extinct group of fishes to which it belongs. As pointed out by Prof. Cope, this genus is not related in any way to the Sturgeons, notwithstanding the contrary assertions of several observers; and the plates of the head-shield are shown to be arranged much as in *Coccosteus*, *Dinichthys*, and the other Arthrodira. The hinder part of this shield, it is stated, "does not seem to have protected the brain, but rather the anterior part of the vertebral axis, and seems to have been a nuchal plate." Exactly the same opinion has already been expressed in reference to the so-called "occipital region" of the Scottish *Homosteus* (Proc. Zool. Soc. 1891, pp. 198–201). The base of the cranium in an Arthrodiran is now described for the first time, Professor Cope's specimens of *Macropetalichthys* displaying a good deal of this region; and the detailed anatomical description is followed by a discussion of the relationships of this type of fish in the light of the new facts adduced. On the whole, Prof. Cope is inclined to accept the conclusion arrived at in the British Museum Catalogue of Fossil Fishes; namely, that the Arthrodira are extremely specialized Dipnoi. "The nuchal portion [of the head-shield of *Macropetalichthys*] with its lateral nuchal elements is represented by the cartilaginous mass which extends posterior to the median occipital bone in *Ceratodus*, in which this region has very much the form of the nuchal shield in *Macropetalichthys*, although it is relatively shorter. The chordal groove with its descending laminæ resembles much the produced occipital bone of *Lepidosiren*. The parasphenoid in both *Lepidosiren* and *Ceratodus* is produced posteriorly abnormally, and it is only necessary to imagine this part to be reduced to its normal length to have the conditions found in *Macropetalichthys*. The broad parasphenoid and vomer remind one of that of *Ctenodus*. As I have shown that *Macropetalichthys* is allied to *Dinichthys*, we can add in favour of the supposition of affinity to the Dipnoi the peculiar dentition of that genus. The ectetramerous structure of the dorsal fin shown by Von Koenen and Traquair to exist in *Coccosteus*, and shown to be probably present in *Dinichthys* by Newberry, are in favour of the Dipnoan theory."

Prof. Cope evidently continues in the belief that *Pterichthys* and its allies have no connexion whatever with the Arthrodira; and the researches of Dr. Rohon quoted above come as a welcome confirmation of this view. Dr. Rohon points out that the histological structure of the shield of *Pterichthys* is very different from that of *Coccosteus*, and closely similar to that of *Pteraspis*, *Tremataspis*, and their allies. This result also confirms the arrangement of the early fishes in question in the second part of the British Museum Catalogue.

Prof. Cope's remarks on the limbs of *Holonema* and *Megalichthys*, however, are far from satisfactory. In the first place, we venture to re-affirm that the so-called dorsal shield of *Holonema* is really the ventral shield turned the wrong way forwards; and the genus belongs to the Arthrodira, not to the Ostracodermi. The limb referred by Prof. Cope to *Holonema* is the distal segment of the arm of *Bothriolepis*, originally named *Stenacanthus* by Leidy. It is stated that "the spine differs from that of both *Bothriolepis* and *Pterichthys* in being without complete segmentation;" on the other hand, we may remark, the distal half of the arm of *Bothriolepis* is nearly always incompletely segmented. With regard to the paired fins of *Megalichthys*, which are said to "approach those of the Arthrodira very distinctly," we venture to assert, from a knowledge of other Osteolepidæ, that the apparent simplicity of the arrangement of the cartilages in Prof. Cope's specimens is due to imperfect preservation, while the paired limbs of the Arthrodira are far too imperfectly known to admit of comparison.

The final result of Prof. Cope's researches in the Crossopterygian ganoids is of great interest, and briefly summarized in an amended classification, which we propose to consider elsewhere on a future occasion. The Professor is at last converted to the belief that the Palæoniscidæ and Platysomidæ are closely related to the primitive

Sturgeons; and he concludes his memoir by the description of two new species of *Platysomus*, one from the Permian of the Southern Indian Territory, the other from the Coal-Measures of Mazon Creek, Illinois. A. S. W.

III.—The Story of the Hills: A Popular Account of Mountains and How they were Made. By Rev. H. N. Hutchinson, B.A., F.G.S. (London, Seeley & Co., 1892.)

POPULAR works on geology are rapidly multiplying, and it becomes more and more difficult to devise any new method of treatment of the subject. Mr. Hutchinson's little book, however, is a pleasing novel version of the old story, interwoven with much interesting information outside the geologist's sphere and illustrated by very beautiful photographs of scenery. There are also numerous extracts from Ruskin's "Modern Painters," from Geikie's "Scenery of Scotland," and from other well-known prose-writers and poets that help to enliven the volume. Mr. Hutchinson's style is terse and clear, without technicalities, and thus precisely adapted to the general reader for whom the "Story" is intended.

The first section of the book deals with mountains as they are. The functions of mountains as barriers between races of men, as retreats for conquered tribes, and as influencing climate, are treated in succession. Mountain plants and animals are then discussed, with special reference to the Alps of Central Europe.

The second and larger section of the book is concerned with the manner in which mountains were made, and is purely geological. Mr. Hutchinson compares the making of a mountain with the building of a cathedral, describing in succession the three processes of "transportation, elevation, and ornamentation" of the materials. Volcanic mountains also have a special chapter; and the volume concludes with some general considerations on the age of mountains.

On all points the information is varied and well up to date, and Mr. Hutchinson's little book may be recommended alike to the school-boy naturalist and to the ordinary mountain-climber who desires to know something of the nature of the peaks and passes among which he spends his holiday.

IV.—Catalogue of the Type Fossils in the Woodwardian Museum, Cambridge. By Henry Woods, B.A., F.G.S. (Cambridge, University Press, 1891.)

THE Woodwardian Museum contains so large a series of fossils to which reference has been made in published works, that a Catalogue like the present will prove of much value to all who are actively engaged in palæontological research. More especially is this the case, since the Woodwardian Professor has full power to exercise his discretion in lending the specimens under his charge to competent investigators far from the University of Cambridge. It is now possible to determine at a glance whether or not any particular type or described specimen occurs in the Woodwardian collection, and much labour and time will thus be saved in making enquiries.

The Catalogue is prefaced by some general remarks by Professor Hughes, who directs attention to the historical interest of some of the older collections in the Museum. The original cabinet of Dr. John Woodward includes that of the Sicilian naturalist, Agostino Scilla, born in 1639; and another collection of the seventeenth century is that of Lister, who opposed the views of Scilla in an article entitled "De Conchitis sive Lapidibus qui quandam similitudinem cum conchis marinis habeant." These are not catalogued in the volume before us, which deals only with the collections of the present century.

Of the principal modern collections an alphabetical list is given in the Introduction. Numerous Upper Carboniferous fossils were obtained from the late Mr. John Aitken. A series of specimens from the Palæozoic formations of Bohemia was purchased from M. Barrande in 1856. The collection of Mr. J. H. Burrows, purchased in 1872, comprises Mollusca and Brachiopoda from the Carboniferous Limestone of Settle. The De Stefani collection of Italian Pliocene fossils was purchased in 1882; and a fine series of British Pliocene fossils, with others from the Cretaceous and Upper Jurassic, formed by Mr. Montagu Smith, was presented in 1883. Mr. Kinsey Dover presented his cabinet of Trilobites and Graptolites from the Skiddaw Slates in 1890; and the Rev. O. Fisher has long been a generous donor to the Museum in many departments. Other donations are the Forbes-Young collection of Chalk fossils, the Goodman collection of Tertiary fossils, and the Walton collection of British Jurassic fossils. The series of Corals, Trilobites, etc., from the Wenlock Limestone, collected by Captain T. W. Fletcher; the Cretaceous collection of the Rev. T. Magee; and the large collection of Mr. John Leckenby, from the Jurassic and Cretaceous of Yorkshire, are other important purchases. Many fossils, chiefly Mollusca and Brachiopoda, from the Inferior Oolite of Somerset and Dorset, were purchased from Mr. H. Monk in 1885; and the large and varied collection of the late Mr. H. E. Strickland was bequeathed in 1888. By the purchase of part of Count Münster's collection in 1840, the Museum acquired a large series of Triassic and Jurassic fossils from the Continent; while the donation of part of Mr. J. Hawkins' collection of Saurians from the Lias in 1856, and the purchase of Dr H. Porter's collection of Saurians from the Oxford Clay of Peterborough in 1866, made important additions to the series of fossil Vertebrata in the Museum. Local fossils have been obtained by innumerable donations and purchases.

The genera and species in the Catalogue are arranged in alphabetical order under their respective classes, and cross-references are given to the synonyms introduced. The list everywhere bears evidence of most careful preparation, and the typography is well arranged for convenience of reference. When so much labour and care have been bestowed, it may appear ungracious to criticize; but we must express the opinion that if Mr. Woods had clearly distinguished between "types" and those specimens merely noticed or figured, his work would have been of much greater use. Moreover, personal expressions of opinion, which may be right or may be wrong, seem quite out of place in a list of this kind, which ought to be nothing more than an index to the *origin* of certain names that have been used in Systematic Palæontology.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—March 23rd, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "On the Occurrence of the so-called *Viverra Hastingsiæ* of Hordwell in the French Phosphorites." By R. Lydekker, Esq., B.A., F.G.S.

The author shows that *Viverra Hastingsiæ*, Davies, is common to the Oligocene of France and Hordwell, and finding that there is no character by which the lower jaw of the type of the latter can be satisfactorily distinguished from the type of *V. angustidens*, Filhol, he considers that *V. Hastingsiæ* is specifically inseparable from *V. angustidens*, and figures the cranium which is the subject of the communication under the latter and earlier name.

He gives a list of seven mammals known to be common to the Headon beds of Hordwell and the Isle of Wight, and the French Phosphorites.

2. "Note on two Dinosaurian Foot-bones from the Wealden." By R. Lydekker, Esq., B.A., F.G.S.

In this paper the third right metapodial (metacarpal?) and an associated phalangeal of a Sauropodous Dinosaur, obtained by Mr. C. Dawson from the bone-bed of the Wadhurst Clay, are described, and referred with doubt to *Morosaurus*.

The author also discusses the relationship of *Acanthopholis platypus* from the Cambridge Greensand.

3. "On the Microscopic Structure, and residues insoluble in Hydrochloric Acid, in the Devonian Limestone of South Devon." By Edw. Wethered, Esq., F.G.S., F.C.S., F.R.M.S.

Microscopic examination of the Devonian Limestones of South Devon shows that they have been built up by calcareous organisms, but that the outlines of the structure have for the most part become obliterated by molecular changes, and the limestones are often rendered crystalline. In connexion with this the author alludes to the disturbances which have affected the limestones. He finds occasional rhombohedra of dolomite, and discusses the probability of their derivation from magnesian silicates contained in the rocks.

A description of the insoluble residues follows. The micas, the author considers, may be of detrital origin, but this is by no means certain; he is disposed to consider that the zircons, tourmaline, and ordinary rutile were liberated by the decomposition of crystals in which they were originally included. Minute crystals, referred to as 'microlithic needles,' resemble 'clay-slate needles,' but are not always straight: they occur in every fine residue, and as inclusions in siliceous and micaceous flakes. The siliceous fragments which enclose them frequently contain many liquid inclusions, which does not necessarily imply any connexion between the two, though there may possibly be some connexion. Micro-crystals of quartz occur, and have been derived from decomposing silicates.

II.—April 6, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "Geology of the Gold-bearing Rocks of the Southern Transvaal." By Walcot Gibson, Esq., F.G.S.

The author describes the general characteristics of the rocks of the Southern Transvaal, and gives a summary of previous work on the area; he then discusses the physical relations of the gold-bearing conglomerates and associated rocks in the Witwatersrandt district, and describes the various rocks in detail.

He concludes that the gold-bearing conglomerates and the quartzites and shales of the Witwatersrandt district (which have undergone considerable metamorphism) form one series, of which the base and summit are not seen; that this series is much newer than the gneisses and granites on the eroded edges of which they rest, and older than the coal-bearing beds which unconformably overlie them; that the entire series associated with the gold-bearing beds has been thrust over the gneisses, and was not originally deposited in its present position, the movements having taken place in two directions, viz. from south to north and from east to west; that, after the cessation of these movements, the strata were injected with basic and sub-basic igneous material, and much of the country was flooded with lavas of the same character; and that the conglomerates have been formed mainly at the expense of the underlying granites, and gneisses which were largely threaded with auriferous quartz-veins and contained larger masses of quartz.

The author then describes the geology of districts outside the typical area, which, though at first sight more complex, are really simpler than that of the typical area. The conclusions arrived at from an examination of these areas confirm the results of the study of the rocks of the Witwatersrandt district.

2. "The Precipitation and Deposition of Sea-borne Sediment." By R. G. Mackley Browne, Esq., F.G.S.

The author discusses the mode of deposition of current-borne sediment upon the ocean-floors, and considers the effects of current-action in sifting the material and causing it to accumulate into stratified linear ridges having directions generally parallel with those of the currents—the dip of the strata varying according to the velocity of the currents. He considers that the conclusions deducible from his analysis appear to be in accord with the evidence afforded by the structure of ancient subaqueous sedimentary deposits.

CORRESPONDENCE.

ARCHÆAN LIMESTONES ON THE FLANK OF THE MALVERN RANGE.

SIR,—The works which have been in progress for some weeks or the new reservoir of the Great Malvern Waterworks on the north-ast flank of the Hereford Beacon have already brought to light a act of no inconsiderable importance in its bearing upon the geology f this most interesting region. Briefly it may be described as ollows:—The reservoir is to be formed by a huge dam to be contructed across the deep valley which runs down from the north-astern flank of the Beacon, between the two most northerly of the our spurs or buttresses which most geological writers on the istrict have noticed abutting upon the Triassic plain of the Severn. t is in the deep wide trench which has been excavated for the undations of this dam that the limestone is best exposed. The ock is a compact crystalline limestone, with a more or less distinct edding, though much jointed in all directions, as if by incipient rushing, probably somewhat dolomitic, of a light-grey colour on esh fractures, but in the more decomposed portions stained with xides of the heavier metals; secondary crystals of calcite are often rmed in quantity on the divisional planes of the rock.

Of *the age of the rock* (which so far appears to be absolutely nfossiliferous) there cannot be very much doubt. As the field-elations show that it cannot be younger than the complex of lavas nd altered tuffs and volcanic muds of the hills between which the alley lies, a complex of rocks which two of the most capable udges on this question (Drs. Callaway and Hicks) refer to the 'ebidian (later Archæan). My first visit to the spot was in company ith Dr. Callaway, about a week ago; and the suggestion that the ock is one "archæan limestone of chemical origin" was made by im. On a second visit yesterday with my friend Mr. H. D. Acland, f Malvern, I was able to follow the exposition which the foreman f the works gave of its position in relation to what he called the whin-rock." It strikes nearly north-west, and dips at an angle of bout 80°. It alternates with the "whin-rock," which seems related o it as an "interbedded trap" (as if the two rocks were contempor-neous portions of the Pebidian series of this locality), or possibly, rom the fact stated to us that the limestone is "softer and easier to ork against the "whin" (as if the latter were intrusive), even omewhat older than the volcanic series. Macroscopic examination f some specimens seemed, however, to indicate contemporaneity by he apparent presence of pyroclastic materials in some portions of he limestone.

The presence of limestones (even massive limestones) in the later rchæans is known; and until quite recently it was generally ssumed in this country that they illustrate those extreme views of 'regional metamorphism" so much in vogue, the metamorphism aving been so complete in such cases as to have obliterated all races of organic remains. In 1888 I challenged that view, on the ground of the much greater probability of a directly *mineral origin* of such limestones, as the necessary result of chemical reactions, which a common-sense application of known laws of thermal and general chemistry tells us must have taken place in the earlier ("pre-oceanic") stage of the history of our earth. This was put plainly enough before the geological world in my "Metamorphism of Rocks" (Longmans, 1889), pages 6–16; and it is needless that I should do more now than refer the reader to that work, so far as concerns the theoretical bearings of the facts here narrated.

MALVERN. A. IRVING.
13th April, 1892.

REPLY TO PROF. J. F. BLAKE.

SIR,—There is only one point in Prof. Blake's reply in your April Number that I intend to notice. Prof. Blake writes:—"General McMahon says he was considering capillary flow under heat and *pressure*, but in his paper he really only discusses the action of heat, and the present discussion on the effect of pressure is a new one." This statement is really a very extraordinary one. In my paper in the GEOLOGICAL MAGAZINE (February, 1892, pp. 74, 75). I simply refer to statements regarding pressure made in my original paper (Proc. Geol. Assoc. vol. xi. pp. 431, 432). In this last paper I showed that pressure was a very important factor, and I gave very interesting statistics at pp. 438, 439 (then published for the first time) supplied to me by an eminent engineer showing that in the case stated, the actual measured pressure at 190 feet below the surface, was equal to the calculated pressure, and was no less than 80 lbs. on the square inch.

I do hope for the future success of "The Annals of British Geology," that Prof. Blake will devote a little more attention to the mastery of the papers he attempts to boil down. Unless he does so, I am afraid that his geological Bovril will not prove a very stimulating or nourishing article.

20, NEVERN SQUARE, C. A. MCMAHON, Major-General.
10th April, 1892.

CONE-IN-CONE STRUCTURE.

SIR,—If Mr. Young's statement[1] is meant to be of universal application, it is certainly not borne out by observation. A radial arrangement of the cones about a large nodule is, I believe, not an uncommon thing. Good examples occur in the Lingula Flags of Borth near Portmadoc, which contain flattened nodules, extending along the bedding, sometimes several feet long. Each is surrounded by a layer of well-characterized "cone-in-cone," and the apices of the cones are directed inwards towards the nodule, so that they point downward on the upper side, upward on the lower side, and horizontally on the edges of the nodule. I have noticed the same thing on a smaller scale in the shales of the Yorkshire Lias.

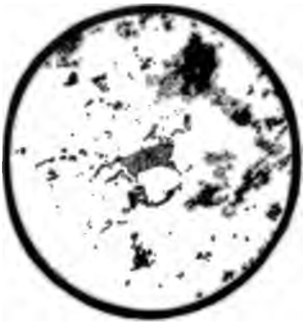
ST. JOHN'S COLL. CAMB. ALFRED HARKER.

⁂ The Editor regrets that, through inadvertence, this letter has been delayed in publication.—EDIT. GEOL. MAG.

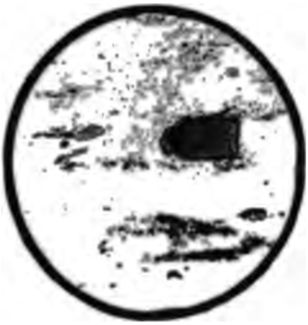
---

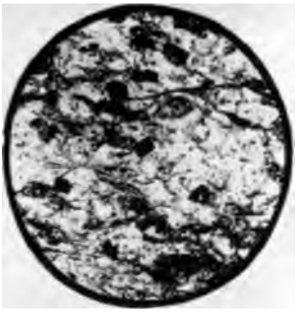
[1] See GEOL. MAG. for March last, p. 138.

1

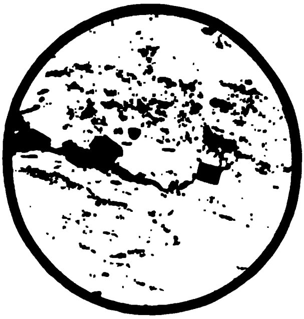


2





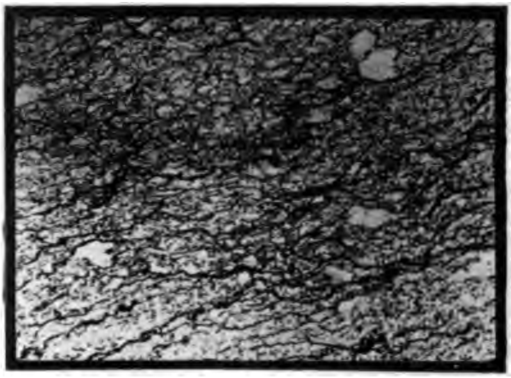
3

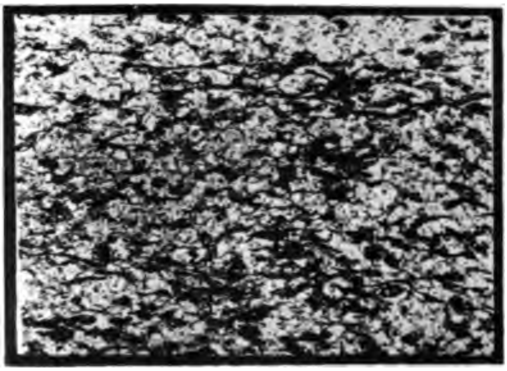


4

To illustrate Mr. Hunt's Paper on the Rocks of South Devon.

1





2

To illustrate Mr. Hunt's Paper on the Rocks of South Devon.

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IX.

No. VI.—JUNE, 1892.

ORIGINAL ARTICLES.

I.—ON CERTAIN AFFINITIES BETWEEN THE DEVONIAN ROCKS OF SOUTH DEVON AND THE METAMORPHIC SCHISTS.

By A. R. HUNT, M.A.

PART I.

(PLATES VI. AND VII.)

IN submitting the following paper to the readers of the GEOLOGICAL MAGAZINE, I am conscious that some apology is needed for entering upon so difficult a subject. My position is as follows:—In 1879 the late Mr. E. B. Tawney joined me in the investigation of a series of detached blocks trawled from time to time by the Brixham fishermen. The character of certain of these stones having suggested to Mr. Tawney the idea that the schists of South Devon might possibly be of pre-Cambrian age,[1] he visited the district in 1880, with the expectation of being the first to advance that hypothesis. The evidence of the schists themselves failed to satisfy Mr. Tawney on the point in question, and his premature death prevented his attacking the problem on a subsequent occasion, as he had hoped to be able to do.

On Mr. Tawney's death in December, 1882, Prof. Bonney was good enough to take his place in supplying me with microscopic analyses of the Channel blocks. In the following Easter, a week spent among the metamorphic rocks of South Devon resulted in a paper published in the Quarterly Journal of the Geological Society, in November of the same year, in which Prof. Bonney expressed the opinion that the South Devon schists might be safely regarded "as Archæan, and as a prolongation of the *massif* so distinctly indicated in the Lizard, to which also belonged the gneiss of the Eddystone," Q. J. G. S., vol. xl. p. 23.

It may be observed that the original investigation of the Channel blocks was undertaken for the purpose of elucidating, if possible, the Start and Bolt problem, and that my first paper was lent to Mr. Pengelly in MS. for use in preparing his own paper, "The Metamorphosis of the Rocks extending from Hope Cove to Start Bay." The two were published in sequence at the Ilfracombe meeting of the Devonshire Association in 1879.

In 1879 Mr. Pengelly maintained the Devonian age of the metamorphic schists. During 1880–82 Mr. Tawney reserved his opinion, having failed in his search for evidence of their pre-Cambrian age. In 1883 Prof. Bonney, without much hesitation, proclaimed the Archæan age of these troublesome rocks.

---

[1] Trans. Devon Assoc. vol. xxi. p. 468.

Under these circumstances there seemed nothing for me to do but to continue collecting facts, and to await the issue of events.

In 1887, 1888, and 1889, Mr. A. Somervail published three papers in the Transactions of the Devonshire Association, in which he suggested that the chlorite schists might be the representatives of the Devonian diabases which appear on the coast line of Start Bay, and in the neighbourhood of Dartmouth.

Early in 1891, Mr. W. A. E. Ussher was good enough to allow me to accompany him on two occasions when mapping the Devonian rocks between Dartmouth and Slapton Sands. Being much impressed by the many obvious analogies between these rocks and the metamorphic rocks further south, I determined to examine and compare as many varieties of the two sets of rocks as I could obtain.

My self-appointed task, then, has been to endeavour to ascertain what affinities, if any, can be detected between the metamorphic rocks of South Devon and the slates grits and volcanic rocks which lie to the northward of them; the green rocks being compared with the volcanics, the mica-schists with the slates, and the quartz-schists with the fine grits or sandstones.

At first sight the quartz-schists and grits seemed the least promising of the different rocks selected for comparison; but on Mr. Harker finding detrital tourmaline in one of the Devonian grits, and the same mineral being subsequently detected by myself in a quartz-schist from near Start Point, these siliceous rocks took a foremost place in the investigation.

THE QUARTZ-SCHISTS AND GRITS.

A geologist examining the classical area of Devonian rocks which forms the northern shore of Torbay between Hope's Nose and Hesketh Crescent, will not fail to notice the frequent interbedding of slates and grits (the latter often in bands too thin to be dignified by the name of sandstone), and that both rocks are often more or less micaceous.

A slice of a brown sandstone from the quarry on the path east of Kilmorie is seen in the microscope to be composed chiefly of fine grains of quartz, of which the larger average about $\frac{1}{200}$ inch in diameter, some of them being splinters with angles absolutely unaffected by attrition or solution; among these may be noticed an occasional flake of white mica, a few scattered fragments of tourmaline, and two or three grains of triclinic felspar.

Another specimen from the same quarry is a fine hard lead-coloured sandstone bedded in well-marked laminæ, which determine its fracture under the hammer; the surfaces of these planes of fracture being highly micaceous.

The bands of grit between slates are sometimes crossed by quartz-veins which do not invade the adjacent slates.

In the cliffs at the north-east end of Slapton Sands we meet with slaty rocks with interbedded grit bands, in which latter mica is occasionally very conspicuous. The rocks here are less generally micaceous than those between Hope's Nose and Meadfoot in Torbay, but a reddish grit-band sliced for the microscope proved almost identical, except in colour, with the brown Kilmorie sandstone already mentioned; even to a few grains of triclinic felspar.

The cliffs at Torcross are passed unexamined, as there are some seven volcanic bands of more or less importance in them, and the sedimentary rocks in consequence liable to intermixture with volcanic ejectamenta.

Just south of the village of Beesands some interesting grits occur, about the spot where Sir Henry de la Beche placed the boundary-line of the metamorphic rocks. Again we meet with fine sandstones and interbedded grits and slates, the sandstones and grits occasionally containing tourmaline and mica, like the rocks at the north-east end of Slapton Sands, and those in Torbay, already described.

At a point on the coast, south of Start Farm and west of Start Lighthouse, among schists much crushed and altered, there occur occasional bands of quartz-schist, which in general appearance, in their constituents of quartz-grains, mica, and tourmaline, as well as in their intercalation between beds of a more slaty nature, recall to mind, both macroscopically and microscopically, the micaceous and tourmaline-bearing grit-bands of Torbay, Slapton Sands, and Beesands.

The undoubted Devonian sandstones may be traced into the undoubted metamorphic quartz-schists by four independent lines of inquiry, viz. by way of iron ores, tourmaline, mica, and quartz.

Iron Ores.

A slice of a grey micaceous sandstone (No. 5) from south of Beesands contains much brassy-looking pyrites crystallizing in cubes, rectangular prisms, and derivative forms.[1] The pyrites is occasionally seen to pass into red hæmatite. With strong oblique sunlight on the slide the characteristic colours of these minerals are well seen.

A slide (No. 22) from a grit-band between slates on the north shore of Southpool Creek, not far from the metamorphic boundary, contains a minute rectangular prism of pyrites, and flakes of red hæmatite.

In Hope Cove, south of Hope Headland, and therefore within the metamorphic boundary, a siliceous band occurs which, while showing no trace of its original quartz-grains, retains its pyrites in cubes and rectangular prisms.[2] The majority of these crystals display the brassy colour of pyrites, and occasionally characteristic striæ are seen. In one group of twinned crystals, a crystal is composed partly of yellow pyrites and partly of bright red hæmatite—whether in this case the latter is a pseudomorph or only a surface incrustation is uncertain.

In a slide from one of the slightly altered bands of quartz-schist south of Start Farm (No. 6) a cube of red hæmatite occurs which is apparently a pseudomorph after pyrites, as the latter mineral has not been noticed in either of my nine slides of these quartz-schists, whereas red iron oxides are abundant.

---

[1] Plate VI. Fig. 3.

[2] Plate VI. Fig. 4.

Black granules and streaks, apparently magnetite, occur in all the above four slides, but as they in no instance exhibit the characteristic octahedral crystallization of that mineral, their evidence is only of minor importance. It is well worthy of notice that in three of these four slides, two being from the metamorphic district, and one from outside the boundary, we have pyrites intimately associated with hæmatite, either in the same crystal, or as a pseudomorph; and further, that on either side of the boundary we find pyrites crystallized in the somewhat uncommon form of rectangular prisms.

Tourmaline.

Tourmaline has been noticed in ten slides from the following six Devonian localities, viz. quarry near Kilmorie, Torbay; north-east end of Slapton Sands; cliffs south of Beesands; grit band in Southpool Creek; near East Charleton; and Aveton Giffard: and in eight slides from two bands of quartz-schist on the coast south of Start Farm, in the metamorphic area. In every case the larger grains are clearly of detrital origin, the only exception being in one or two instances in the quartz-schist, where secondary tourmaline has crystallized on the original grains, and these secondary crystals have been swept to a distance by differential movements in the rock.[1]

No alteration by pressure or solution has been observed in the tourmaline grains in rocks north of Beesands, the first indication noticed being south of that village.

In a reddish grit containing much hæmatite (No. 59), a well-characterized light-brown crystal of tourmaline is broken sharply in two, and slightly dislocated. Clear quartz fills the intervening gap without in the least dissolving the edges of the tourmaline crystal.[2]

A grain of tourmaline in another slide from the same neighbourhood (No. 5) is slightly, albeit distinctly, affected by solution, with indications of the re-crystallization of secondary tourmaline.

In a slice (No. 16) of one of the quartz-schist bands south of Start Farm, two crystals of tourmaline may be especially noticed: one, a longitudinal section, with characteristic transverse cracks; the other a basal section. In each case there is a considerable growth of secondary tourmaline on the original crystals; and in each case also, by a slight differential movement of the rock, fragments of this secondary tourmaline have been detached and moved to a small distance from the parent crystal.

We have thus close together in the same field of view detrital tourmaline and induced tourmaline.[3] The origin of the latter would be obscure, were not all the steps of the process so clearly set forth. Tourmaline occurs in many forms and colours; but the tourmalines of Beesands and the Start coast are identical.

---

[1] Plate VI. Fig. 2.

[2] Plate VI. Fig. 1.

[3] Plate VI. Fig. 2.

Quartz-grains.

The quartz-grains in the sandstones north of Beesands do not call for particular notice. Just south of Beesands we have seen quartz filling the interstices of a broken tourmaline, and in another case a grain of tourmaline slightly affected. Professor Bonney's description of a rock from the same locality seems exactly to cover the case, viz.: "The rock has evidently been much compressed, and some slight amount of mineral change has taken place" (Q.J.G.S. vol. xl. p. 18). An occasional quartz-grain contains liquid inclusions and bubbles, but without any distinguishing features.

A slide of a Devonian grit-band from Southpool Creek (No. 22) contains more than one quartz-grain of interest. One grain showing considerable solution at the edges abounds in hair-like inclusions together with an occasional fluid inclusion with bubble. Another grain is crowded with fluid inclusions, some of which contain very active bubbles, while others take the form of negative crystals.

In a slide (No. 8) cut from the specimen of quartz-schist from Start Farm, given me by Mr. A. Somervail, we find a quartz-grain with hair-like inclusions; and in another slide from the same stone (No. 10) we have a grain with bubbles in negative crystals. These two grains resemble the two in the Southpool Creek slide already referred to.

However, the most interesting feature in the quartz-schist lies in the fact that the rock has not been submitted to pressure and heat sufficient to obliterate entirely the original tourmalines and quartz-grains, and that a comparison with the sandstones and grit-bands of Beesands and Southpool Creek is still possible. In the case of the quartz-schists at the Bolt Head, further west, tourmaline is absent, and the obliteration of original structures in the quartz is complete; thus a comparison with the Devonian sandstones on this particular point is not possible.

Mica.

On first collecting the Devonian micaceous sandstones for comparison with the Start schists, the possibility that the mica in either case might be detrital had not been entertained. On Mr. Harker pronouncing the Slapton Sands mica detrital,[1] and that in the Start quartz-schists possibly so,[2] the origin of the Devonian and metamorphic micas became a problem of importance.

If the metamorphic rocks were micaceous before their alteration, the presence of much of their mica might be accounted for with much less dynamical and chemical metamorphosis than is at present demanded for them.

In the case of the sandstones and quartz-schists, it is easy to find Devonian sandstones much more highly charged with mica, than the Start quartz-schist under consideration, in which, as Mr. Harker remarks, the mineral is only sparingly present, *e.g.* the sandstones and grit bands of Kilmorie, Meadfoot, Slapton Sands and Beesands, to go no further a-field than the coast-line. Both the sandstones and quartz-schists contain mica varying between the minutest filmy flake, hardly seen in the microscope, and flakes sufficiently apparent to the naked eye. Given a small amount of solution in the silica of the quartz-grains, so that the mica flakes might be free to partially rearrange themselves, and there seems to be no reason why the Start quartz-schist under consideration should not have been derived directly from such a rock as the Kilmorie sandstone, without any development of newly-formed mica.

---

[1] Appendix, Slide No. 3. [2] Appendix, Slide No. 8.

So far as I understand it, a theory held by some is that the Devonian slates and sandstones when micaceous are with very few exceptions "Phyllites," in which the mica is considered to be an induced product; and that the mica-schists are rocks in which the mica has also been induced but to an incomparably greater extent, so that the rocks differ in kind. It seems, however, possible, that the converse of this may be true, and that with some exceptions the mica in both the Devonian and metamorphic rocks is, or was, originally, detrital, the deposition of micaceous sediment being much more general in the southern area than further north. Irregular deposition is occasionally exemplified in the Torbay rocks, in which worm-tracks in slates are filled with fine micaceous silt.

In the foregoing pages the iron ores, tourmaline, micas, and quartz-grains of the Devonian sandstones have been connected with the iron ores, tourmaline, micas, and quartz-grains of the metamorphic quartz-schists. It cannot be doubted that were the rocks further examined by a competent mineralogist, other points of resemblance would be noticed, for minute grains of felspar, unless well defined, and the rarer minerals, are beyond the power of my microscope and knowledge to distinguish.

One noticeable feature which the grits and quartz-schists possess in common is the abundance of laminæ of iron oxides: at Hope's Nose, black; at Kilmorie, brown; at Slapton Sands, red; at Beesands, black and red; at the Start, black and red. The colours being probably due to the brown, red, and black, oxides of iron. The following remark of M. Daubree is worth noticing, although the black oxides of the Start schists do not take the form of crystallized magnetite:—

"Dans certaines localités des Ardennes, les cristaux de fer oxydulé, qui imprègnent les ardoises se sont logés suivant les longrains, et font ainsi ressortir des joints rudimentaires qui, ailleurs, ne sont pas reconnaissables à la vue."—Geol. Experimentale, vol. i. p. 336.

At the Start we find the quartz-schist traversed by numerous little cracks cemented by opaque iron-ores.

THE MICA-SCHISTS AND SLATES.

The mica-schists of the metamorphic district, as distinguished from the schists in which quartz is the most prominent mineral, have not been examined to any extent.

One specimen of a red schist, which I thought might compare with the red Devonian slates, is described by Mr. Harker as a rock which "may have been originally a shale or slate with some gritty bands."[1] Mr. Harker could not have more precisely described the cliffs at the north-east end of Slapton Sands, with whose shales or slates I desired to connect the red mica-schist from the Start, had he been intimately acquainted with the locality instead of being a perfect stranger thereto.

End of Part I.

EXPLANATION OF PLATES VI. and VII.

Plate VI.

Fig. 1.—Crystal of tourmaline in fine Devonian Sandstone, four chains south of Beesands. (59) Magnified about 37 diameters.

Fig. 2.—Crystal of tourmaline in quartz-schist, Start Farm. Formation of secondary tourmaline with partial dislocation of same. (16) Magnified about 37 diameters.

Fig. 3.—Rectangular iron pyrites in fine Devonian Sandstone, north of Tinsey Head. (5) Magnified about 18 diameters.

Fig. 4.—Rectangular iron pyrites in siliceous band, South of Hope Headland. (52) Magnified about 18 diameters.

Plate VII.

Fig. 1.—Quartz-schist, Start Farm. Remnants of original quartz grains. (Compare "Grain of Quartz-sand in the Mica-schist of Arroquhar." Presidential Address of Dr. Sorby, F.R.S., Proc. Geol. Soc. 1880, p. 86, Fig. 9.) Magnified about 12 diameters.

Fig. 2. Fine Devonian Sandstone, north of Tinsey Head, with schist-like alineation of iron ores and greenish mica. Magnified about 12 diameters.

I am much indebted to my friend Mr. W. M. Baynes, of Torquay, for valuable assistance in the preparation of my photographs for publication.

(*To be continued.*)

II.—Permian in Devonshire.

By W. A. E. Ussher, F.G.S., etc.

(By permission of the Director-General of the Geological Survey.)

IN the course of a visit to the Hunsruck district between Treves and Bingen in the spring of 1890, in company with Professor Gosselet, Mons. C. Barrois, Herr von Reinach and Herr Grebe, I was struck by the resemblance displayed by the Permian quartz porphyry of the valley of the Nahe, between Birkenfeld and Bingen, to fragments contained in the breccias of Teignmouth. In discussing the South Devon section with the two gentlemen last named, on that occasion, they both gave it as their opinion that the lower beds of the Devon section might prove to be representatives of the Rothliegende.

In the pressure of other geological work, I had no time to carry the matter further, until May, 1891, when Herr von Reinach spent a week with me in examining the South Devon coast section and the eruptive rocks in the vicinity of Exeter and Crediton. He then expressed the opinion that certain parts of the lower New Red rocks of Devon corresponded very closely with members of the German Permian, but that this correspondence was not borne out in consecutive horizons. In the Teignmouth breccias with numerous fragments of claystone porphyry, quartz porphyry, etc., he detected a strong resemblance to the Rothliegende (Upper Söterner) of the Nahe, above the volcanic horizon (Grenz schichten). In the Volcanic rocks of the Exeter and Crediton areas he recognized the equivalents of the Grenz schichten (Middle Söterner). Herr von Reinach also pointed out to me the similarity presented by some of the thick even-bedded red and whitish sandstones intercalated with marls to the east of Exmouth, to the Upper Bunter Sandstones of the Moselle, recalling to my mind sections I had seen near Treves and in the Eifel.

---

[1] Appendix, Slide 24.

On the 10th of last February Herr von Reinach wrote me as follows:—"Professor Bücking had the kindness to determine the melaphyres and tuffs I brought with me from the environs of Exeter. As I do not intend to publish these facts, I authorize you, also in the name of Professor Bücking, to make use of this communication. You know that we have at the Nahe—(1) Melaphyres in the Older Rothliegende which are only intrusive; (2) Melaphyre Covers (Melaphyr decken) which we have only in the Söterner (Grenz schichten) of the Rothliegende. The Grenz Melaphyre has been divided by Lossen into Upper, Middle, and Lower, which types are generally the same throughout the Nahe district." Prof. Bücking's identifications are as follows:—

Spencecombe, Knowle Hill (Crediton Valley)	Mesokeratophyr or Orthophyr. Biotit Melaphyr with Olivine.
Posbury, near Crediton Pocombe, near Exeter	Melaphyr with Olivine.

Dunchideock, between Exeter and Chudleigh.—Melaphyr with Olivine and Bronzite.
Yeoton, near Crediton.—Tuff.

Herr von Reinach adds: 'The Dunchideock Melaphyr is identical with our type of the uppermost Melaphyr roof zone (Dach zone) of the environs of Kreutznach on the Nahe.'"

Although the detailed mapping of the eruptive rocks associated with the New Red of Devon was completed about fourteen years ago, I have published nothing specially on that subject, certainly not from lack of materials. In 1876 Mr. Rutley visited all the chief localities with me, and determined the rock for the Geological Survey; these determinations have been lately confirmed by Dr. Hatch, and they agree with the determinations of Prof. Bücking; of this Herr von Reinach was not aware, but the fact rather enhances than lessens the importance of the communication he has so kindly authorized me to impart.

If we assume the correlation of the New Red volcanic rocks with the Grenz-schichten as established, the probable correlations with the Nahe section might be as follows:—

Dawlish breccias	Upper Rothliegende.
Teignmouth breccias	Lower Rothliegende. (Söterner beds with volcanic rocks).
Basalts (local)	
Watcombe and Petitor conglomerates	

It must, however, be borne in mind that no correlations framed on a partial, or even intimate acquaintance with the South Devon coast section only, can be regarded as conclusive. The local clusters of volcanic patches from Exeter northwards may not be on the same horizon. As regards the Bunter, if we assume the Straight Point (east of Exmouth) Sandstones to be Upper Bunter, this probable correlation favours the Middle Trias age assigned to the Lower Marls in 1878. No evidence has been adduced to invalidate my classification of the Keuper from the Pebble beds of Budleigh Salterton upwards. I may say that Mr. Geo. Spencer Perceval, in three letters to the "Western Morning News" in 1877 or 1878 (I forget which year), disputed my classification of the Budleigh Salterton Pebble bed in the Keuper, maintaining that it represented the Bunter Pebble beds; this naturally deprives Prof. Hull's recent communication to the Geological Society of the charm of novelty for me.

My old friend Mr. P. O. Hutchinson, of Sidmouth, in 1878, found remains of an Equisetum-like plant in greenish shaly sandstone in the lower part of the Keuper Marls near Sidmouth; this occurrence suggests a possible comparison with the "Schilf (Reed) sandstone" of the Middle Keuper of the Eifel. But an Equisetum (*E. Mougeoti*) occurs in the Upper Bunter sandstone of the Eifel as Herr von Reinach informs me, so that no reliance can be placed on this suggestion. I take this opportunity of recording the recent discovery (a few months ago) of quartz porphyry giving place upwards and outwards to a rock resembling a mica andesite and identical with specimens from one of the volcanic patches associated with the New Red of the Crediton Valley. This discovery was made at the eastern termination of the Thurlstone New Red Outlier. In connexion with it I quote the following passage from my paper[1] before referred to:—"The breccias frequently contain igneous fragments distinctly referable to the destruction of such igneous patches as those of Washfield, Kellerton, etc. The outflow of these lavas seems generally to have accompanied or heralded the earliest deposition of Triassic sediments in the districts in which they occur; *nor does it appear impossible that the eruption of quartz porphyries may have been in some way connected with their appearance.*"

The late Professor Ramsay inspected the New Red Rocks in 1880, and failed to find any sufficient proof for the correlation of the lower breccias with the Permian of the Midlands. There is not a shred of proof that the two areas were connected until the Keuper, and probably at a late stage in that period. The Midland sections owe their importance as a basis for correlation entirely to the merits of the assumed correctness of their classification with reference to the German types. For much information on the characters of the German types I am indebted to my friend Herr von Reinach, whose acquaintance with them is most intimate. Until I have the opportunity of availing myself of his kind offer to show me the rocks on the ground, or until new facts are brought to light in Devon, I fail to see that the literature of the New Red Rocks of Devon and West

---

[1] Quart. Journ. Geol. Soc. for Aug. 1878, p. 462.

Somerset,[1] supplemented by the present communication, will be benefited by the addition of more speculative correlations.

My friend Dr. Hatch has kindly sent me the following notes on specimens of the New Red Volcanic rocks of South Devon.

Notes on Sliced Specimens of the Exeter "Traps," in the Collection of the Geological Survey at Jermyn Street.

Olivine-basalt or *melaphyre*, composed of lath-shaped striped felspars and scattered grains of magnetite, with calcite, replacing augite, and ferruginous pseudomorphs after olivine.

Localities: Raddon Court (No. 951), Pocombe (No. 953), between Chiphele and Budlake (No. 958), and Quarry near Crabtree, Kellerton (No. 945).

Porphyrite (*Andesite*): A felted aggregate of lath-shaped and microlitic striped felspars, with occasional porphyritic crystals of plagioclase. *Localities*: Western Town, Ide (943), Quarry N.E. of Knowle, N.E. of Holcombe-Burnell (946), and Knowle Quarry, W. of Dunchideock (949). The last two, with rounded (corroded) grains of quartz.

Mica-porphyrite (*Mica-andesite* or *trachyte*).— Finely vesicular rocks containing brown mica, imbedded in a minutely microlitic ground-mass, which is generally rather obscured by the presence of dusty magnetite and secondary calcite.

Localities: Kellerton Park (Nos. 944, 947 and 950). The nature of the felspar in these rocks is indeterminable, but specimens from Copplestone (Nos. 957 and 959) consist of a holocrystalline aggregate of broad lath-shaped crystals of orthoclase, flakes of brown mica and magnetite.

III.—DID THE MAMMOTH LIVE BEFORE, DURING, OR AFTER THE DEPOSITION OF THE DRIFT.

By HENRY H. HOWORTH, M.P., F.G.S., etc.

IN recent papers which I have printed in the GEOLOGICAL MAGAZINE I have tried to show that some of the greatest mountain chains in the world are of very recent origin; and that this accounts for their showing no traces, or very slight ones, of the action of ice on a wide-spread scale.

I have, in fact, ventured to lay down the conclusion that the presence or absence of such traces of ice-action is a test of whether these mountains existed at the so-called Glacial period or not.

If my view be right, it follows that very large masses of land were thrown up suddenly or very rapidly in post-Pliocene times; and, if this was so, it is very probable that there was a great subsidence of land in other parts corresponding to this upheaval. I believe that this can be proved, and that it involves some important and interesting considerations worth discussing. Before we can deal effectively with this problem, however, we must settle another one equally important and equally interesting, to which I propose to devote a few pages, namely, the precise geological horizon where we are to put the Mammoth and his companions, including Palæolithic man.

---

[1] GEOL. MAG. for April, 1875; Quart. Journ. Geol. Soc. Aug. 1864; February, 1870; Nov. 1876; Aug. 1878; Transactions of Devonshire Association, 1877, 1878, 1881; and the Proceedings of the Somersetshire Archæological and Natural History Society for 1889, vol. xxxv.

It is at once a reproach to geology, and a good proof of the very great difficulty there is in making our way among the latest geological records, that there should be any doubt upon such a question. The fact is nevertheless so, and has given rise to a sharp polemic elsewhere in quite recent years. I am bound to say that I myself have changed my views on the subject in view of the evidence, and have to recant some phrases I once printed in this MAGAZINE.

I wish to speak with some precision in the matter, and not to be misunderstood. The point I would discuss is not whether the Mammoth lived before, during, or after the so-called Glacial period, but whether the beds in which his remains are found, when undisturbed, underlie or overlie the Drift, or are intercalated with it. The two questions are not, as is often assumed, the same, and it is to the latter alone that I wish my criticism to apply.

I must also define the kind of evidence which I alone think conclusive. I altogether distrust any evidence on the point except that of superposition. Evidence based upon inferences of different kinds I have always mistrusted in deciding this critical question, but I would go further. We must remember that the Till or Boulder-clay contains extraneous bodies of different kinds, which are often far-travelled, and sometimes not so. Among these bodies there may be tree-trunks or molar teeth of Elephants, which may be as true boulders as those of granite and gneiss and like them derived from elsewhere. Whatever theory we adopt in regard to the Till, we must concede that it picked up far-travelled débris in its march, and mixed it in many cases with the débris of the underlying beds, sometimes with Chalk, sometimes with Lias, sometimes with sandstone and mixed this débris with the fossils from these different beds. It is further clear that ice would take up and convert Mammoth teeth into boulders just as readily as Ammonites and Belemnites, and that the former would be no more contemporary with the Till nor evidence of an interglacial climate than the latter are. Let us now turn to the evidence.

The earliest discovery of Mammoth remains in Scotland took place in the year 1817. "When," says Sir A. Geikie, "the Till covering the sandstone at the quarry of Greenhill in the parish of Kilmaurs, in Ayrshire, had been partially removed, there were found at a depth of 17½ feet from the surface, two Elephant's tusks. . . . The matrix in which they were found was a clay, which around the bones changed from its usual light brown colour into a dark brown, with a most offensive smell when turned over. The tusks lay in a horizontal position with several bones near them. Dr. Scouler visited the quarry about 1840, and reports that seven more tusks had subsequently been found there (Trans. Geol. Soc. Glasgow, vol. i. pt. 2, pp. 68–69). Some antlers of the Reindeer were also found along with an Elephant's tusk at this quarry (*id.* p. 71).

These remains were found in a clay containing, inter alia, *Astarte compressa* and *Leda pygmæa*, with eight genera and nine species of *Foraminifera*, and five genera and ten species of *Ostracoda*, and also a number of seeds of plants and fragments of beetles. The earlier writers described this clay as Boulder-clay. Dr. Bryce, in 1864, opened some pits at the place, and found that the beds in which the remains occurred *underlie* the Till, and he put them on the same horizon as the Forest Bed. Mr. Craig and Mr. Young, in 1869, after a close examination of the district and the position of the beds in regard to the Boulder-clay, satisfied themselves that the Mammoth and shell-bed were pre-Glacial (see Trans. Geol. Soc. Glasgow, vol. iii. p. 310). The officers of the Geological Survey in their commentary on Sheet 22 describe the bed as inter-Glacial; but after sifting the evidence again, and writing in 1887, Mr. Craig says: "I see no cause to change the conclusions arrived at in our joint paper of 1869." Dr. Bryce's surmise that the fossiliferous bed may be the equivalent in age of the Cromer Forest Bed is, in my opinion, not far from being correct. Elsewhere he says he places the beds at the very base of the Glacial deposits (Trans. Geol. Soc. Glasgow, vol. viii. pp. 213–223).

According to Mr. J. Geikie, these remains "occurred in a peaty layer between two thin beds of sand and gravel, *overlaid by Till or Boulder-clay*, and resting directly on the sandstone rock of the quarry" (Great Ice Age" p. 605).

A horn of a Reindeer was also found in the basin of the Endrick, in the parish of Kilmarnock, about four miles from Loch Lomond. "The section in which it occurred," says Sir A. Geikie, "consisted first of the vegetable mould, then of a stiff clay 12 feet thick, containing a large quantity of stones, underneath which was a bed of blue clay about 7 feet thick, *at the lower part of which, close upon the* underlying sandstone, the antler was found, and near it a number of marine shells. The deposit was estimated to be about 100 to 103 feet above the sea-level" (Trans. Geol. Soc. Glasgow, vol. i. pt. 2, pp. 70, 71; see also Dr. Smith, Edinb. New Phil. Journ. n.s. vol. vi. p. 105).

The next locality where Mammoth remains occurred in Scotland was during the excavation of the line of the Union Canal, between Edinburgh and Falkirk. This was in 1820. A large mass of Boulder-clay having been undermined fell into the cutting, and among the earth was found a tusk measuring 39 inches in length. It had lain about 15 or 20 feet from the surface. Mr. Bald, to whom the discovery was reported, examined the place. He says it was found from 15 to 20 feet from the surface. He did not actually take it out of the clay, and only judges that it must have come out of it from its excellent state of preservation (Wernerian Society, vol. iv. p. 60). It has subsequently been described as having been imbedded in the heart of the stiff clay. If it had been so, it can only be treated as a boulder, since it was quite detached; this is suggested by Mr. Bald, and it in no way evidences an old land surface; but it seems to me there is no warrant for describing it as having come out of "the heart of the stiff clay."

A skull of *Bos primigenius* was found in 1868, near Croft Head in Renfrewshire, imbedded some few feet deep in a soft clay or mud, interlaminated with lines and beds of sand, and occasional layers of fine gravel. In some of the layers of clay there was a little vegetable matter in a state of decay. These beds were *overlain* by Till full of scratched stones (Geikie, GEOL. MAG. Vol. V. p. 393, etc.).

In a paper on this deposit, in Vol. VII. of the same MAGAZINE, Mr. Geikie says that it subsequently yielded remains of the Horse and Irish Deer. He reaffirms the opinion that the overlying clay in this instance is the true Boulder-clay, that it is *in situ,* and in no sense due to a landslip.

On the 6th of March, 1879, there was exhibited before the Geological Society of Glasgow a well-preserved molar of a Mammoth found four years before in sinking a pit on Mainhill Farm, near Baillieston, east of Glasgow. It was found in a bed of purely laminated sandy clay, at a depth of 33 feet below the present land surface, the sand bed being from 40 to 45 feet thick, and resting directly upon the rock-head or Coal-measures without any intervening Till or other superficial strata. In cutting the line of railway leading to the pit, the sand bed was seen to be overlapped by a thick bed of stiff dark-coloured Boulder-clay full of large travelled stones, which thinned away as the pit was approached, and the sand bed rose to the surface. Mr. Young remarked that here we had another instance of the occurrence of the Mammoth in Scotland during pre-Glacial times, and he went on to remark that in all the cases which had occurred in Scotland, the Mammoth remains he says "had either been derived from pre-Glacial beds below the Till or from the Till itself. Dr. Geikie has never been able satisfactorily to show that the Mammoth-bearing inter-Glacial beds, in any of the places where they have been found, rested on an older Boulder-clay, although he says that at other spots, such as Kilmaurs, intercalated beds are found in the same district between the two Tills; but unfortunately for his contention, these beds have never as yet yielded any Mammoth remains, nor any of the other organisms found associated with them. When traces of the Mammoth have been got in Boulder-clay, they may in all probability have been derived from the denudation of pre-Glacial beds in the same district" (Proc. Geol. Soc. Glasgow, 1878-9, p. 291).

In January, 1882, there was exhibited before the Glasgow Geol. Soc. a fragment of a tusk of the Mammoth which had been found in sinking a pit on the farm of Drummuir, Dreghorn. This was found in a bed of sand *underlying* 76 feet of Boulder-clay (Trans. Geol. Soc. Glasgow, vol. viii. pt. ii. p. 213, etc.).

In a paper by Messrs. Craig and Young, in the third volume of the Trans. of the Geol. Soc. of Glasgow, they say, *inter alia,* that if we look at the recorded instances of the occurrence of the Mammoth and Reindeer in Scotland, we shall find that in the majority of cases they either have been found in beds below the Boulder-clay or in that deposit itself. Those found in the Boulder-clay may have been derived from the denudation of pre-Glacial beds. In the one or two instances where the Mammoth has occurred in beds more recent than the Till, they may still have been worked out of it. Bearing on the pre-Glacial age of the Reindeer in Scotland, they refer to a portion of the right antler of a Reindeer found in the Boulder-clay at Raes Gill, Carluke, Lanarkshire. "The specimen bears evident marks of transportation, its burr, browtyne, and other extremities being worn and rounded, and the whole surface has a smooth, polished, ice-scratched appearance, exactly like that we meet with amongst the ice-worn stones of the Till. It was found in Till several feet thick" (*op. cit.* pp. 310–320).

Let us now turn to England. No remains of Pleistocene mammals have occurred so far as I know in the counties of Northumberland, Durham, Cumberland, or Westmoreland.

Of the few cases of the discovery of Mammoth remains in Lancashire and Cheshire, the only one, according to my friend Prof. Dawkins, in which the relation of the deposit to the Boulder-clay is clear, was the famous case of the discovery made by Mr. Bloxsom in March, 1878, in digging a shaft for the new Victoria Salt Co. near Northwich, of a fragment of a molar. It occurred at a depth of 65 feet in a bed of sand overlying the red Keuper marls, and *overlaid* by 37 feet of brown Boulder-clay (Q.J.G.S. Feb. 1879, pp. 140–141).

If we turn to Yorkshire, the evidence is more abundant and more conclusive.

In a Memoir on the Moors, Mountains, and Sea-Coast of Yorkshire, published by J. Phillips in 1853, he urged that the lowest Hessle gravels, which rest upon Chalk, and are covered by Boulder-clay, as well as the contents of Kirkdale cave, are pre-Glacial. Writing in 1868, he says of this view about the Hessle gravels: "I am still disposed to favour this opinion; in the first place, there is no proof that these beds are marine, but a strong presumption to the contrary, from the considerable abundance of land Mammalia found in them, especially *Elephas primigenius* and Horse; and secondly, beds of this order composed of chalk and flint fragments, not only are not known to occur in the midst of the Boulder-clay, but can hardly be imagined to exist there; and, thirdly, the Boulder-clay rests on them without conformity (Q.J.G.S. vol. xxiv. p. 255).

Phillips continued during half a century to be the advocate of the Mammoth beds being older than the Drifts, and in the last edition (1875) of his Geology of Yorkshire, in describing the ossiferous marls of Bulbecks, near Market Weighton, shows that they lie directly on the red marls; and in regard to their relative age, he says: "It appears to be proved, both by comparison with the analogous deposits at Hessle and Bridlington, and by the superposition of the ordinary diluvium in the south-eastern part of the Vale of York, that the latest of these inundations (*i.e.* that which laid down the Mammoth beds) was anterior to the movement of waters which brought many Cambrian rocks through the pass of Stainmoor and dispersed them over the hills and valleys and antediluvial lake deposits of Yorkshire" (*op. cit.* pp. 12–19).

Speaking of the Hessle beds containing Mammalian remains, he says: "As they are now covered up by a great thickness of clay and pebbles derived from a far greater distance (*i.e.* by the Drift), we count them the spoils of pre-Glacial land" (*id.* pp. 57, 58).

Teeth of Mammoths sometimes occur in the Boulder-clay in Yorkshire as they do elsewhere, but are clearly derivative and boulders. Phillips has remarked how in certain places only the teeth occur, and no other parts of the skeleton (*id.* p. 74); when bones occur under these circumstances, they are always scattered and generally rolled (*id.* p. 170).

In regard to the deposits in Kirkdale cave, he points out their analogy with those occurring at Bulbecks, "where glacial drift overlies the bones," adding "that Kirkdale cavern was occupied in the pre-Glacial condition of the land which is now Yorkshire was my earliest opinion, and seems still to be the most probable inference in the present state of knowledge" (*id.* 169–171).

This opinion about Kirkdale cavern is interesting, for the evidence is fast accumulating to show that the cavern deposits at all events are older than the distribution of the Till. I should like to refer to another northern cavern, where, although no Mammalian remains occurred, there seems to have been a very decided invasion of Drift.

Speaking of the cavern at Stainton-in-Furness, Mr. Cameron says: "The floor of a gallery resembles the bed of a dry mountain torrent, being strictly strewn with water-worn pebbles and boulders. Soft yellow clay occurs, frequently also gravel; while again in other places there is a pavement of hard dry clay split up by cracks into octagonal-shaped masses. . . . In this gallery are also Silurian boulders, often cemented together in huge masses. A few of these boulders are of a larger size than to have allowed of their entrance through the as yet only known inlet to the place. Ireleth, about 4½ miles off, is the nearest place where this rock is *in situ*, and boulders and fragments of rock are often met with, thrown against each other in the direst confusion as if impelled along by a very strong current and suddenly stopped" (GEOL. MAG. Vol. VIII. pp. 312, 313).

We will now turn to the famous Victoria Cavern, where a considerable polemic arose in regard to the interpretation of the facts. It must be remembered that this discussion was before the more recent discoveries of Dr. Hicks, etc., in North Wales. Prof. Dawkins, who took the view in the paper that the remains in this cave were post-Glacial, says in the discussion that he could not say whether the Victoria Cave was pre-Glacial or Glacial, nor even define its relation to the Glacial period. The age of the clays was, he said, a matter of opinion (Q.J.G.S. vol. xxxiii. p. 612).

Other explorers of the cavern were much more emphatic in their view. Mr. Tiddeman, who drew up the report to the British Association, distinctly refers the deposit to a pre-Glacial age, and speaks of the Craven savage as having lived before the Great Ice-sheet (Rep. Brit. Assoc. 1875, p. 173).

In a paper on the Cave by the same author, he tells us how a bed of tenacious clay with scratched Silurian and other boulders was found underneath all the talus at the mouth of the cave, resting on the edges of the beds containing the older mammals, and dipping outwards at an angle of 40°. Mr. Tiddeman explains this as the remnant of a moraine (lateral or *profonde*) which dammed up the mouth of the cave and prevented anything but water charged with fine sediment from entering it during the Glacial period. Perhaps, he adds, one of the strongest pieces of evidence, that the older cave animals lived in this district only at a time previous to the great ice-sheet, is that, so far as we know, the remains of none of them (except of *Cervus elephas*) have ever been found in any of the post-Glacial deposits of this district. Though so common in the river gravels in the Midland and Southern Counties, they are never found except in caves until we get much further south or east. Leeds is, I belive, the nearest locality where they occur. This would seem to imply that their remains were wiped off the area by the great ice-sheet, . . . and only left in the shelter of caves to which it could have no direct access" (Geol. Mag. Vol. X. p. 15).

Writing in "Nature," the same geologist says, "A human bone or fibula was certainly found beneath glacial clay in the Victoria Cave" (Nature, vol. xiv. p. 505). A dispute arose afterwards as to whether the fibula was human or not, but this does not affect the issue we raise. Mr. Tiddeman again says, "In the Victoria Cave the surroundings are such that nothing but an ice-sheet could have sealed up with glacial clay the remains discovered by the Committee. . . . The origin of the boulders, their position, the ice-scratches on the rocks hard by, all point to the time of greatest glaciation, when the whole district was covered in with ice and snow of great thickness. And the agent which closed the cavern and concealed the animals within it must have been the same which swept the country clean of their remains all around further than the eye can reach" (*ib.* 506.)

In the discussion on Prof. Dawkins' paper, Sir A. Ramsay said he thought the evidence for the existence of Man in the Victoria Cave before the Glacial period was stronger than that against it. Prof. Prestwich thought the deposits in the Victoria Cave were pre-Glacial (Q.J.G.S. vol. xxxiii. p. 612).

The next case to which I shall refer is one in which we have not to deal with Mammalian remains, but with the Southern freshwater shell the *Cyrena fluminalis,* which marks the Pleistocene horizon in other places.

In 1861 Professor Prestwich read a paper before the Geological Society of London on the occurrence of *Cyrena fluminalis* over beds of Boulder-clay near Hull. He says there was previously no evidence of direct superposition to show the age of the shell. I quite agree with him that for this reason the instance in question is important if maintainable. Is it so? In the first place in the pit where the

Cyrena occurred in thousands, and of which Mr. Prestwich gives a section (Q.J.G.S. vol. xvii. p. 450), *no Boulder-clay at all occurred.* Secondly, in another section at Paull Cliff, near Hull, where the *Cyrena* also occurred in fewer numbers, there *was an underlying clay*, but Prestwich admits that inasmuch as it contained neither boulders nor fossils, he could not feel certain about its being the Boulder-clay" (*id.* 452). Mr. Prestwich then had some experimental borings made, but they did not succeed in piercing the gravel, and therefore, in his own words, "failed to obtain the exact proof" (*id.* 453). Hence the evidence as tested by this locality utterly fails. Now it is curious that while Mr. Prestwich failed to find Boulder-clay in a definite position in regard to the gravels, Messrs. Wood and Rome did, and they say: "The gravel of Kilscar Hill, the subject of the notice of Mr. Prestwich, is (now that the ballast pit has been more extensively worked) shown most distinctly *to be overlain by the Boulder-clay, no less than* 15 *feet of it being so exposed in one part*; and they add that there are no means of ascertaining at present on what it rests (Q.J.G.S. vol. xxiv. p. 153).

Let us now turn to the evidence of the Mammals. This also seems to be very conclusive. I will first refer to the well-known memoir by Mr. C. Reid on the Geology of Holderness. In this memoir, chaps. v. and vi. are headed "Inter-Glacial Beds." I do not know why, for I confess I can find no evidence of their *inter-Glacial* character. That is, however, another issue.

Mr. Reid objects, on the evidence of the fossils, to Professor Phillips treating the Hessle gravels as pre-Glacial, an argument in which I do not quite follow him. He admits that at Bridlington they rest directly on the Chalk (*op. cit.* p. 48), that is, have no Boulder-clay or true Drift below them. There some Mammalian remains have occurred in a buried cliff, which has since been very carefully examined by Mr. Lamplugh, to whom I shall refer presently. His conclusion that this bed underlies the basement bed of the Glacial series is confirmed by an observation of Mr. Reid, who says, that a similar bed of chalk-gravel, in borings at Bridlington Harbour, rests on the Chalk, and is clearly beneath the Basement clay (*id.* p. 49).

Turning to the Hessle Mammaliferous gravels on the Humber, Mr. Reid admits that they also unmistakeably rest directly on the Chalk, and are covered and overlapped by Boulder-clay. Yet he goes on to argue that "we have nothing to fix the age of the Hessle gravel by, and that there is no positive evidence whether another underlying Boulder-clay has been denuded or not." If so, why call the bed inter-Glacial? And he goes on to say, "Prof. Phillips's reference of the Hessle gravels to a pre-Glacial period *may turn out*, with fuller evidence, to be well founded." I should have said that it was conclusively proved, there being against it no stratigraphical facts, but merely an *à priori* prejudice based on some theory about the fossils.

A similar bed, but without fossils, at South Ferriby Cliff, on the south of the Humber, also rests on the Chalk, and is overlain by Boulder-clay.

In regard to the marine gravels in which Professor Prestwich found the *Cyrena fluminalis*, and which have yielded many Mammalian remains, Mr. Reid admits that at one spot, at Kelsey Hill, a face of about 12 feet of weathered Boulder-clay, with small stones, can be seen *overlying* the gravel (*id.* p. 54).

Mr. G. W. Lamplugh, in his paper on the Drifts of Flamborough Head recently published, is most clear on the subject. He describes the buried cliff at Sewerby as having been formed by marine action prior to the deposition of any of the Glacial beds, and as having afterwards been buried and obliterated by the accumulation of materials banked against it (Q.J.G.S. vol. xlvii. p. 394). In a later paper, where he enters into greater detail, he puts the Sewerby gravels, which have yielded so many Pleistocene Mammalian remains, distinctly *under* the whole Glacial series, and notably under the so-called basement bed. He comes to precisely the same conclusion in regard to the marine shell bed at Speeton (*op. cit.* pp. 410–412). In the discussion on this paper Mr. E. T. Newton describes the remains of mammals from Sewerby as just such an assemblage as might be expected in an undoubted Pleistocene deposit.

It seems to me, therefore, that the Yorkshire evidence, wherever we can test it, agrees with that of Scotland and of Cheshire in compelling the conclusion that the horizon containing remains of the Mammoth and its companions is distinctly below the Drift beds.

(*To be continued.*)

IV.—THE REPORTED OCCURRENCE OF *AMMONITES JURENSIS* IN THE NORTHAMPTON SANDS.

By S. S. BUCKMAN, F.G.S.

IN the GEOLOGICAL MAGAZINE (Dec. III. Vol. VIII. No. 329, p. 493, Nov. 1891), Mr. E. T. Newton has a "Note on the Occurrence of *Am. jurensis* in the Ironstone of the Northampton Sands in the Neighbourhood of Northampton." This note had especial interest for me, from my having contested Mr. Beeby Thompson's view of the *Jurensis*-zone being represented by the clayey beds beneath the Sands; and, in fact, it seemed to support my argument. Further reading, however, obliged me to confess that I could not claim this support; for Mr. Newton says (p. 494), "that the specimens of *Am. jurensis* agree exactly with Dr. Wright's plate 79 (Lias Ammonites)."

Now, in 1887, I pointed out that this form of Wright's was very different to Zieten's *jurensis*, and that it occurred in the *Opalinum*-zone;[1] and, in 1888, having occasion to refer to it in some sections, I named the form afresh *Lytoceras Wrighti.*[2] Further, the same form is figured by Branco, under the name *Lytoceras dilucidum* on the authority "Dumortier (non Oppel)."[3]

The form called *Lytoceras Wrighti* differs materially from Zieten's original *Am. jurensis* in the amount of involution, the extent of compression, the very different-shaped umbilicus,[1] and the broader whorls. Even if the term 'species' be interpreted in a very liberal sense, to include both forms as *jurensis*, the differences remain the same. Wright's fossil is not the typical *jurensis*; and, moreover, it is a form characteristic of the *Opalinum*-zone. Whether it be regarded as a different species, or only a mutation of *jurensis*, it is advantageous to mark its differences by a name—*Lytoceras Wrighti.*

---

[1] Inferior Oolite, etc., Proc. Cotteswold Club, vol. ix pt. ii. p. 134, footnote, 1887.

[2] Monogr. Lias Amm. pt. ii. p. 44, footnote, Pal. Soc. 1888.

[3] Untere Dogger, Abh. geol. spez. karte Elsass-Lothringen, Bd. II. pl. i. fig. 8.

The evidence of the *Jurensis*-zone in the Northampton Sands is thus narrowed down to *Am. insignis.* The typical form is highly characteristic of the *Jurensis*-zone; but there are several mutations and allied species which are characteristic of the *Opalinum*-zone. For instance, the "*Insignis* var.," which Newton says agrees with Wright's pl. 75, figs. 1–3, is quite an aberrant form of *Hammatoceras* (*Insignis*-group). It differs especially from *insignis* in ornamentation, and in having ventral furrows. As it is not named, to my knowledge, I think it might appropriately be called *Hammatoceras Newtoni.* It occurs in Dorset quite high up in the *Opalinum*-zone. Its nearest allied form is *Am. Alleoni*, Dumortier, of the same zone, which is less coarsely ornate, less sulcate, and more involute.

So far the bulk of Mr. Newton's evidence seems to indicate the Northampton Sands being the *Opalinum*-zone, a conclusion I expressed in Monogr. Amm. p. 53, 1888. The occurrence of *Am. Murchisonæ* in the *Opalinum*-zone has been noted by myself and several other authors; but the real head-quarters of *Murchisonæ* are on a distinctly higher level than the head-quarters of *Opalinum.*

As regards the *Jurensis*-zone in Northamptonshire, my position is simply agnostic. I know no Ammonite-evidence,—barring, perhaps, Mr. Newton's "*insignis*"—to show the existence of any of the four levels—*Dumortieria*-, *Dispansum*-, *Striatulum*-, *Variabilis*-beds—of this zone, which are easily recognized by an abundant Ammonite-fauna for about 80 miles from Haresfield to the Dorset coast; but the species of some or all may ultimately be found to occur in the Northampton Sand, and I doubt not in the same successional order.

Of the *Opalinum*-zone there is good evidence for the existence of the upper level *Opalinum*-beds; of the lower level, *Moorei*-beds, *Lytoceras Wrighti* appears to be the only evidence. This is not sufficient—see sections Monogr. Amm. p. 45, et seq.

A summary of the species allied to or similar to *A. jurensis* may be useful in this connexion. As their genealogy, synonymy, etc., will be given more fully in a future paper, only the briefest notice will be made.

1. *Am. jurensis*, Zieten. Oval whorls, very little involute. Very rare. Burton Bradstock, Yeovil Sands.

2. *Am. perlævis*, Denckmann (usually called *jurensis*). It differs only in being more compressed ventrally, and having a more pronounced inner margin. Scarce. *Dispansum*-beds, Cotteswolds.

3. *Am. phyllicinctus*, Quenstedt. Like the last, but more evolute.

---

[1] The umbilicus of the typical *Wrighti* is basin-shaped, that of the typical *jurensis* wider and graduated.

Only a fragment. Bottom Yeovil Sands (*Dispansum*-beds), Bradford Abbas.

4. *Lytoceras sigaloen*,[1] n. sp. S. Buckman (***Ammonites jurensis***, d'Orbigny (non Zieten), Pal. franç. pl. 100). It has been thought that this is the species Oppel intended to call ***Amm. dilucidus***; but Oppel's reference is to Quenstedt's ***Amm. fimbriatus opalinus***, which is that authór's name for ***cornucopiæ***, d'Orbigny (non Young). Further, Oppel says, "that ***Amm. cornucopiæ*** and ***Eudesianus*** are the nearest allies to ***dilucidus***." It is reasonable to suppose that had he meant to call d'Orbigny's ***jurensis*** by the name ***dilucidus***, he would have said "that Zieten's ***jurensis*** was the form nearest to ***dilucidus***." *Lyt. sigaloen* is like ***perlævis***, but more compressed and more involute. A magnificent specimen, 16 inches (406 mm.) in diameter, is in my collection from Yeovil Sands, Haselbury, Somerset.

5. *Lytoceras* ***Wrighti***, S. Buckman. Monogr. page 44, footnote, 2, Pal. Soc. 1888. (***Lyt. jurense***, Wright (non Zieten), Lias Amm. pl. 79.) Like ***sigaloen***, but very involute. Basin-shaped umbilicus. *Opalinum*-zone, Dorset, Somerset, Gloucestershire, etc.

The above species, so far as their suture-lines and inner whorls are known, show clearly enough genetic relationship with ***Amm.*** *Germanii*, d'Orb., ***torulosus***, Zeit., and ***hircinus*** (Schloth.), Quenstedt. They lack entirely the extraordinary lengthy lobes—especially the superior lateral—of the ***Fimbriatus***-group.

6. ***Ammonites linulatus***, Quenstedt (Am. Schwäb. pl. 48, fig. 2), is another form which may belong to the same group. It differs from *jurensis* in having a fan-shaped aperture with a high inner margin. Whorls depressed. Foreign only. ***Jurense***-zone.

Three other species have resemblance, but are not exactly allied to *jurensis*.

7. ***Am. amplus***, Oppel. A quick-coiled, very inflated form. Not known in this country. Relationship uncertain. ***Murchisonæ***-zone.

8. ***Lytoceras confusum***, S. Buckman (***jurensis*** auctorum). A slowly-coiled form with triangular aperture, and marked shoulder. *Concavum*-zone; Dorset. The inner whorls and young specimens sometimes show periodic ribs indicating relationship with ***ophioneum***, Benecke, and ***rasile***, Vacek.

9. ***Amm. trapeza***, Quenstedt. A slowly-coiled, very evolute form, with subtriangular whorls, and more rounded-off shoulder. Very rare. Sherborne-zone with ***Amm. fissilobatus*** (***Sowerbyi***-zone of German authors).

V.—The Revised Astronomical Theory of Glaciation.

By G. W. Bulman, M.A., B.Sc.;
Corbridge-on-Tyne.

IN "The Cause of an Ice Age" Sir R. Ball claims to have removed from the Astronomical Theory of Glaciation the greatest stumbling block in the way of its general acceptance, and to have placed it on a firm and unassailable foundation. And this stumbling block he considers to have been Sir J. Herschel's neous statement, that, of the total heat received by a hemisphere year, one-half is received during the summer, and the other half ng winter.

---

[1] σιγαλόεις, smooth.

r R. Ball has worked out the true distribution of the yearly between the seasons, and arrived at figures about which he ns there can be no question. His result is, that of the total ly heat received by a hemisphere, 37 per cent. is received ng winter, and the remaining 63 per cent. during summer. nting these figures, it is maintained that glaciation follows as cessary consequence, whenever the difference in the lengths of mer and winter is sufficiently great.

his difference in length between the two seasons formed the ting point of Dr. Croll's Theory. It was supposed by him that winter supply of heat being spread over a greater number of s, the temperature would be so reduced, and the snowfall so eased thereby, that finally—with the aid of ocean currents, etc. laciation would result.

nd in showing that only 37, instead of 50, per cent. of the ly heat is received during winter, Sir R. Ball *appears* to have oved a difficulty; 37 per cent. of the yearly heat would certainly maintain so high a temperature as 50 per cent. during the thened glacial winter. But a little consideration will show that removal of the difficulty is only apparent.

ur *present* average winter temperature forms the *starting point* the calculation of what it would be when the winter was at its gest, and this calculation can be made *quite independently of the es* 37 and 50. The *result* will be *the same* whether we assume r 50 per cent. of the yearly heat to be received during winter. *these figures do not necessarily enter into the calculation at all.* y did not, as far as I am aware, enter into that of Dr. Croll, reasoned correctly, that our present winter supply of heat, n spread over 199 days instead of 179, would produce an rage temperature lower in proportion to the lengthening of the on.

he *difficulty* in connexion with the supposition of half the yearly t supply coming in winter is rather that of understanding how inter climate could be produced at all; for our winter being *ter*, *if* it received the *same amount of heat*, would be actually *er* than summer.

ut granted that 50 per cent. of the annual heat supply permits vinter climate during a portion of the year at present, the gthening of the season might be supposed to reduce the temperature asily as on the supposition that the percentage was 37 per cent.

ir R. Ball considers that Dr. Croll was unacquainted with the qual distribution of heat between the seasons, but he has not wn that any of the latter's reasonings or calculations depend on assumption of its equal distribution.

he theory set forth in "The Cause of an Ice Age" is regarded revised form of Dr. Croll's, but the two theories differ in certain ntial particulars. For, in the first place, while the Revised

Theory attributes glaciation solely to the lengthening of one season at the expense of the other—in other words to purely astronomical causes, viz. eccentricity and the precession of the equinoxes—Dr. Croll attributed it to physical agencies brought into operation by these astronomical causes. Among these physical agencies by far the most important is the Gulf Stream. But according to the Revised Theory the deflection of this great ocean current is not required to produce glaciation, and Sir R. Ball supposes it to have flowed much as it does now during the Glacial period. And there are two considerations which seem to show that the Gulf Stream *did* modify our glacial climate, and which were, therefore, difficulties on Dr. Croll's view. The first of these is, that palæontological evidence seems to show, that the western shores of our island were warmer than the eastern—as they are to-day. And the second is, that in North America glaciation extended fully 10° further south than it did here.

Again, while, according to Dr. Croll, the astronomical conditions might occur without leading to glaciation through secondary physical causes, the Revised Theory *requires a group of glacial* periods whenever the eccentricity is sufficiently great. Dr. Croll has indeed shown how the astronomical causes which under certain conditions —of distribution of land and water, etc.—would produce a group of glacial, separated by genial, periods, might, under other conditions, lead to a group of genial periods separated by others a little less genial. And thus—especially in his later writings—he seems to have allowed considerable force to Sir Chas. Lyell's views on the cause of glaciation, though only as adjuncts to the Astronomical Theory.

It is probably in the judicious combination of the two theories that the true solution of the glacial problem will have to be sought.

While, then, the essence of Dr. Croll's Theory consisted in the *continued increase* in the cold, due initially to a lengthened winter, by physical agencies thereby brought into action, the Revised Theory attributes glaciation entirely to the reduction in temperature produced by spreading the winter heat supply over a greater number of days.

The question, then, of how far our present winter temperature would be reduced if its heat supply were spread over 199 days—the longest possible winter—is the critical point in the Revised Theory.

If it can be shown that the consequent reduction of its winter temperature would place our climate on a level with those of countries now glaciated; and that the summer supply of heat—as great as at present though concentrated into fewer days—would be unable to melt the ice and snow, then glaciation follows as a necessary result of the lengthening of the winter. But this has not yet been done.

Sir R. Ball (Appendix pp. 177, 178) gives data from which the reduction in our average winter temperature during the winter of 199 days can be found.

At present he calculates we receive a mean daily average of 0·75 of a heat unit during winter, and when that season is as its longest 0·68, which gives a difference of 0·07. Now each *tenth* of a unit corresponds to a rise or fall of 30°, and hence 0·07 corresponds to $\frac{7}{10}$ of 30° or 21°.

Our present average winter temperature may be taken as 42°, and hence during the long winter it would be 21°. This would give us a climate milder than that of Greenland between the 10° and 0° January isotherms, since its *mean* winter temperature is probably not more than 6° above this.

The climate represented by this winter average of 21° may perhaps be fairly compared to that of America between the 20° and 10° January isotherms which include the southern part of the region of the Great Lakes. That such a reduction in temperature would produce glaciation is not then apparent.

Using a different method of calculation, however, I have arrived at a much lower temperature for the winter of 199 days.

Assuming, as Sir R. Ball has done, that the direct heat of the sun is expended in keeping the earth above —300°, and taking our mean January temperature of 36·9° for convenience of comparison with the January isotherms, we have the following calculation:

336·9°, the temperature maintained by the direct heat of the sun at present, × $\frac{179}{199}$ = 303°, the same when that heat is spread over 199 instead of 179 days.

This gives a mean Jauuary temperature of 3°, or a mean winter temperature of 9°, if we suppose this latter 6° in excess as at present.

This would probably give us the winter climate of some part of that strip of Greenland before alluded to, and lying between the S.E. coast and a line drawn from about Clavering Islands on the east to the point where the Arctic circle cuts the west Coast. This would indicate a climate like that of the above glaciated region; but is it a necessary consequence that such a winter would produce perpetual snow in our latitude?

We must remember that the heat received during summer would be the same in quantity as at present, though concentrated into fewer days; and the question to be decided is, would this heat be sufficient to melt the snow of the previous winter or not? It is not quite obvious that it would be, and the point seems one for careful consideration and calculation.

What, for example, would be the effect on the ice of Greenland if we could transfer our summer there for a few years without altering its winter? One is inclined to suggest that a gradual clearing of the country from *perpetual* snow and ice would take place. And a comparison of the part of Greenland under consideration with the neighbourhood of Lake Superior and Quebec which lies between the same January isotherms is instructive. For while the former is glaciated, the latter is not; nor are those portions of Asia south of 60° N. lat., lying between the same isotherms. And the reason of this is doubtless their much hotter summers. Hence, although our summer heat supply may be less than that of the above regions, it is still sufficiently greater than that of Greenland to make it difficult to believe that a mean winter temperature of 9° would reduce our country to the present state of the latter.

We may, then, conclude that a mean winter temperature of 21°, or even of 9°, does not *necessarily* imply glacial conditions *like those of Greenland at present.*

From Sir R. Ball's data again, the average summer temperature during the most genial period possible, viz. when the summer is 199 days and the winter 166, can be calculated. The present mean daily heat of summer is 1·24, and during the summer of 199 days it would be 1·16. This gives a reduction of 0·08 of a heat unit, and since each tenth of a unit corresponds to a fall of 30°, we have $\frac{8}{10}\times 30°=24°$ as the difference in average temperature between our summer and that of the most genial period. If we take the July isotherms as rough guides to the average summer temperature, this would give us a *Greenland summer* during the most genial period. Such a summer climate can scarcely be supposed to have tempted the plants and animals of the tropics or subtropical regions to wander north to our latitudes.

If, then, the burden of accounting for tropical, or subtropical, as well as glacial periods is to be laid on the Astronomical Theory of Glaciation, the revised form must be declared wanting.

But these reductions of winter and summer temperatures depend largely on the number —300, which has been used in the calculations, and its use requires some justification. If the *whole yearly heat supply* of a hemisphere had been reduced, and not *merely the daily average of winter*; or if the earth in the absence of the sun could *very rapidly* cool down to —300°; then the above calculations might be taken as approximately true. But the yearly heat supply is not appreciably altered. Moreover, the earth—or particular hemisphere under consideration—has a certain temperature due to the heat of the previous summer; and *this temperature must share with the winter heat supply the task of maintaining the hemisphere above* —300°. Suppose this temperature resulting from the heat of the previous summer to be 55°. If, in the absence of the sun, the earth could sink from this to —300° in a few days, then this factor might be neglected.

But supposing that instead of the above rapid rate of cooling it required, say, six months to cool down to —100°; then, instead of —300, we should have to use —100 in our calculations, and this would make important differences in our reasonings. I am not prepared to assert that —100 is the correct number, but it seems almost certain that —300 is too low, and that the earth would not sink to so low a temperature in six months. For the *rate* of cooling of a heated body diminishes rather rapidly with the diminution of its *excess* of temperature. Thus the rate of cooling for an excess of 80° C. is little more than a *tenth* of what it is for 240° C. Again, it has been shown that the rate of cooling diminishes with the density of the surrounding air up to a pressure of $\frac{1}{10000000}$ of an atmosphere. But the earth's heat before it can radiate into stellar space must pass through the exceedingly attenuated upper strata of the atmosphere. Again, if cooling down to —300° within six months were possible, we should expect to find some approach to this in the lowest recorded temperatures of the Arctic regions during the absence of the sun. It is true that in these regions the temperature is modified by warm winds and waters. Yet on still, clear nights, in places removed from the influence of ocean currents, these modifying causes will be reduced to a minimum. I have not myself come across any record of temperature so low as —80°, and even if we suppose it sometimes sinks lower, we have still no indication that —100° is too high for our calculation. And we have to remember, as a set off against the influence of winds and currents, and probable lower temperatures than any yet recorded, that the intense cold of the Arctic regions may be due to other causes besides radiation. The *evaporation* which takes place from the surface of ice and snow itself reduces the temperature already, it may be, far below freezing. Snow, again, falling on the open sea *melts* even in water already below freezing, and thereby adds to the cold.

And there is another consideration which seems to show that —100° or even higher is a more suitable point to reckon from than —300°. According to Sir R. Ball the present difference in the mean daily average of heat between summer and winter is 1·24—0·75, or 0·49. If $\frac{1}{10}$ of a unit means 30° difference in temperature, then ·49 would be equivalent to $30^\circ \times 4{\cdot}9 = 147^\circ$. And our present July temperature is 60°! The average difference between summer and winter is about 20°. This would seem to indicate that —50° is the most correct starting-point.

Taking —200° or —100° as starting-points, then, according to Sir R. Ball's calculation, the tenth of a heat unit will mean 20° or 10° instead of 30°, and the reduction in the average winter temperature would be $\frac{7}{10} \times 20^\circ = 14^\circ$, or $\frac{7}{10} \times 10^\circ = 7^\circ$. This would give 28·3°, or 35·3°, as the average winter temperature during the winter of 199 days.

With these figures, then, the Revised Astronomical Theory seems insufficient to account for glaciation. On the other hand, they permit to a warmer summer during a genial period.

It appears, then, that *a suitable temperature as a basis for calculation is the imperative need of the Theory, and that the use of* —300° *has not been justified.*

In his statements concerning the effects of varying eccentricity and the precession of the equinoxes on the length of the seasons, Sir R. Ball is not quite so clear as might be desired on a point of such primary importance to his Theory. Thus, on p. 95, we find the statement that, "*with the present eccentricity* of the earth's orbit, the great possible difference between summer and winter would amount to 33 *days*. I do not mean that the actual disparity between summer and winter at the present moment is so much as this: it only, in fact, amounts to seven days, because at present the line of equinoxes does not happen to be adjusted in the manner described."

But on page 97 we read: "*When all circumstances combine to* accentuate as much as possible the difference in the lengths of the seasons, one of them may be 199 *days long and the other* 166."

Again, on page 153, we find the statement that seven days is the greatest possible difference between the seasons under present eccentricity: "*So long as the eccentricity of the earth's orbit remains at its present value,* the difference between the lengths of the seasons will fluctuate between *the extreme values* of a winter seven days longer than a summer, and a summer seven days longer than a winter."

Yet, as we have seen, it is expressly stated, on page 95, that the present position of the line of equinoxes is *not* such as to produce the maximum difference possible for the present eccentricity. And on page 167 it is stated that the present seasonal difference is "*near its maximum* for the present eccentricity of the orbit."

The true law is stated on page 152 thus: "The differences between the lengths of the seasons is, as a mathematician would say, a function of two other independent quantities; it partly depends upon the eccentricity of the earth's orbit, and partly on the longitude of the perihelion, that is to say, on the position of the line of equinoxes with respect to the longer axis of the earth's orbit; if there were no eccentricity, there could be no difference in the lengths of the seasons, no matter where the line of equinoxes may lie. On the other hand, no matter what the eccentricity may be, there would be no difference in the lengths of the seasons if the line of equinoxes passed through perihelion." That is to say, for *each* value of the eccentricity the difference in the length of the seasons may vary from zero to a certain maximum value determined by the eccentricity. This maximum difference, Sir R. Ball states, is found by multiplying the eccentricity by 465. Taking ·0167922, the figures given by Sir J. Herschel as the present eccentricity, we obtain 7·8 days as the maximum difference. This maximum will occur when the line of the equinoxes is perpendicular to the major axis of the ellipse of the earth's orbit; and the seasons will be equal when it coincides with the major axis. And by what is called precession of the equinoxes this line describes complete circles round the sun as centre, and thus takes up successively every possible position in relation to the major and minor axes of the earth's orbit.

With the greatest possible eccentricity the difference between the seasons may attain to 0·0745 × 465, that is, 33 days.

In the above quotations the italics are mine.

A slip appears to occur on p. 81 in reference to Fig. 2, p. 82. Instead of "the part *AB* is comparatively near the sun, while the other part *XY*, is as far as possible from the sun," should we not read, "the part *AB* is as near the sun as possible, while the other, *XY*, is comparatively far from the sun"?

And on p. 82, when we read, "it therefore sweeps across from *X* and [to?] *Y* in much less time than it takes to pass from *A* to *B*," the reverse is doubtless intended.

Sir R. Ball has brought forward certain facts in botanical distribution as witnesses of the truth of the Revised Astronomical Theory. The facts, however, seem to me rather to testify against it. The argument is briefly thus:

It has long been known that certain temperate forms of plants in regions far removed from each other and *on opposite sides of the equator*, exhibit a remarkable similarity.

So great is the likeness that it is supposed that those in the south must have migrated from the north, or *vice versa.* They must, then, *have crossed the equator*, and that they did so is a *proof* that equatorial regions were at one time cooled down sufficiently to permit of the existence in them of these temperate forms of vegetation. And the Astronomical Theory *requires* that. equatorial regions in the glaciated hemisphere should be thus cooled down. Thus the botanical facts seems to confirm the Astronomical Theory.

But, although the lengthening of one season will *reduce* its average temperature, that of the other will be *increased* by the corresponding shortening. And if the present heat of the tropics during summer in our northern hemisphere would be fatal to temperate plants, much more would it be so during glaciation when the summer supply of heat was concentrated into 166 days. A calculation of what the temperature of the glacial summer would be from Sir R. Ball's figures will perhaps make this more obvious. The mean daily heat during the glacial summer is given as 1·38, and at present as 1·24, which gives a difference of ·14. Now if ·1 of a heat unit corresponds to 30°, ·14 will correspond to 42.° Taking the present average temperature of our equatorial regions as 80°, this gives 122° as that of the glacial summer!

The botanical facts, then, seem to testify that if a glacial period helped the plants over the equator, glaciation was not brought about according to the Revised Astronomical Theory.

In seeking in the stratified rocks for evidence of the numerous glacial periods which must, according to the Astronomical Theory, have occurred in the past, Sir R. Ball's method of interpreting the record has at least the merit of novelty. Dr. Croll, and other geologists, when in search of such evidence have weighted themselves with the necessity of finding scratched and polished boulders, erratics, and other deposits analogous to those formed during the latest ice age. Sir R. Ball has rid himself of this impediment, and finds in the *ordinary alternation* of stratified beds *a record of alternate mild and glacial epochs.*

The scarcity of evidence of former Ice Ages, sufficient to satisfy the average geologist, is well known, and has hitherto formed one of the most—if not *the* most—serious stumbling blocks in the way of the Astronomical Theory of Glaciation. And the Revised Theory suffers more in this respect than did that of Dr. Croll. For according to the former glaciation follows as a necessary consequence, whenever the requisite astronomical conditions occur, viz. whenever by combination of high eccentricity and the approach of the line of equinoxes to a position perpendicular to the major axis of the earth's orbit, the difference in length between the two seasons becomes sufficiently accentuated. Dr. Croll, on the other hand, has shown, as we have seen, that according to his views, the astronomical conditions may occur *without* leading to glaciation. Hence, according to the Revised Theory, a larger number of glacial periods in the past is necessary, and hence a larger amount of evidence of such should be expected from the geological record.

The *imperfection of the record* doubtless accounts for much, yet it is difficult to believe that glacial periods could have occurred in the past with the frequency demanded by the Revised Astronomical Theory without leaving much more evidence of their occurrence than has yet been forthcoming.

In conclusion, I have not wished in the foregoing remarks to show that the Astronomical Theory is insufficient to account for glaciation. I have rather endeavoured to call attention to certain calculations which will have to be made, and certain facts which will have to be established before the Revised form can be generally received as a satisfactory explanation. Thus it will have to be shown, by careful calculation and comparison with existing climates, that the reduction of the average winter temperature by the lengthening of that season would be sufficient to produce in our latitudes a snowfall comparable to that of Greenland at the present day. And granting such a snowfall, it will have to be shown that all the heat of the succeeding summer—*the same in amount as now*—would be insufficient to melt it. And in order to calculate the reduction in temperature, due to the lengthening of the winter, a suitable datum line of temperature will have to be fixed upon, after a careful consideration of the numerous factors involved.

The supposed confirmation of the Astronomical Theory in the present distribution of temperate plants north and south of the equator, I have endeavoured to show is rather a contradiction, since the burning heat of the equatorial summer during glaciation would render the passage of such plants across the equator even more unlikely than it is to-day.

I have demurred again to the suggestion that Sir R. Ball's discovery removes any difficulty from the older Theory of Dr. Croll, and have drawn special attention to the essential differences between the two views. I have pointed out that the newer view more urgently demands evidence of former glacial periods in the geological record, and noted the easy way in which Sir R. Ball proposes to meet this demand.

REVIEWS.

I.—Geology of the Central Himalayas. By C. L. Griesbach, C.I.E., Superintendent, Geological Survey of India. Memoirs of the Geological Survey of India, Vol. XXIII. 1891, pp. 232, Pls. 27, Phototypes in the text 31, and 2 Maps.

By the term 'Central Himalayas' the author includes that portion of the system of mountain ranges fringing the southern margin of the the Tibetan Highlands, in which the head-waters of the Ganges drainage are situated, and which extend to he north-west as far as the Sutlej gorge. Within this area the entral Himalayas may be divided into a Northern range, in which s the water-shed of the region, and a Southern range which contains he highest peaks. This latter is mainly formed of crystalline rocks, hiefly gneisses and metamorphic schists, whilst the Northern range s almost entirely composed of a vast thickness of sedimentary trata ranging from the lowest Palæozoic to late Tertiary. This emoir mainly relates to the character of these sedimentary deposits, which are now elevated so as to form a high rim round the southern dge of the great high plateau of Húndés, which in its lowest portion is 12,000 to 16,000 feet above sea-level. The principal geological features of this region have already been made known in the works of General Strachey and Dr. F. Stoliczka; the present report, which is the result of nearly twelve years' investigation, very materially adds to our knowledge of its geological structure, and in some respects considerably modifies the descriptions of the earlier writers.

The region under consideration is indeed a wild one; a large part of it is above the line of perpetual snow, which in the Southern range is between 15,000 and 16,000 feet above the sea, and in the Northern somewhat higher. Nearly every valley above these elevations has its glacier, and some of these range from five to sixteen miles in length. A fact, interesting to glacial geologists, is noted by the author, viz. that during years of observation he failed to find striated and polished boulders in the moraines of these glaciers, whilst the bounding rock-walls of the glacier-valleys do not show the smooth and rounded surfaces, usually seen in other regions, and it is supposed that subaerial denudation and rapid weathering has obliterated the ice-markings. From the presence of morainic material at lower levels, the author concludes that the glaciers must formerly have extended much further than at present. In one respect the geologist has an advantage in these high mountain regions, for the rocks are not hidden by vegetation, and in the absence of snow the main stratigraphical features can be noted readily even from a distance.

The main mass of the Himalayas consists of an enormous thickness of crystalline rocks, in which two systems can be recognized; an older of granitic gneiss, which is now known to be metamorphic granite; and a younger series of micaceous schists, talcose rocks, phyllites and gneiss, to which the name of "Vaikrita" system is applied. Both the lower gneiss and Vaikrita systems are interpenetrated by veins and masses of eruptive granite, which also traverse the next overlying Haimanta rocks.

The lowest distinctly sedimentary rocks, which rest, without any clear line of division, on the Vaikrita schists and gneiss, consist at their base of thick beds of conglomerate and purple quartzites, succeeded by shales and phyllites, and limited above by a zone of bright red quartz shales, with an estimated thickness altogether of 4000 feet. This series, named the "Haimanta" system, is probably the equivalent of the Cambrian and older divisions, and may correspond with Strachey's azoic slates. The only organisms yet found in them are traces of Crinoid-*stems, casts* of bivalves and of Bellerophon.

'Conformably succeeding the Haimanta rocks in the sections between the parallel ranges of the Central Himalayas, is a series of shaly quartzites alternating with coral limestones about 300 feet in thickness, which, on the evidence of the fossils, are referred to the Lower Silurian, and resting on these are quartzite beds about 1000 feet thick, which are placed as Upper Silurian, although the fossils in them have not yet been fully determined.

Next in ascending order are dark limestones, about 650 feet in thickness, containing Corals, Crinoids and Brachiopods, which are doubtfully placed as Devonian; following these are red crinoidal limestones considered to be Lower Carboniferous and white quartzites and dark limestones with *Productus*, belonging to the Upper Carboniferous. In Spiti, limestones containing *Athyris royssii*, *Productus*, etc., probably represent the highest beds of the Carboniferous in this region.

According to Mr. Griesbach's experience, there is a gradual passage between the different Palæozoic formations in the Himalayas, and from the phyllites and quartz shales of the Haimantas or Cambrian, to the Upper Carboniferous, there is a perfect and continuous sequence without the slightest unconformity. There are evidences of considerable physical changes at or near the close of the Carboniferous period, and the strata of this age are in places unconformably overlapped by shales with *Productus*, considered to be Permian. The interruption between the Carboniferous and Permian is followed by another long interval without a break, which continued until after the deposition of the Liassic limestones.

The Permian *Productus* shales, not over 250 feet in thickness, are followed by the lowest beds of the Triassic series containing *Otoceras*. This series in the Northern range of the Himalayas consists mainly of limestones, dolomites and shales, in all about 4000 feet in thickness. The resemblance between the Triassic rocks of this region and the Alpine facies of the same formation, long since recognized by Salter, Strachey and Suess, is confirmed by Griesbach, who divides this series into Lower, Middle, and Upper, corresponding respectively to the Bunter, Muschelkalk, and Keuper of Germany. The Rhætic series of the Himalayas consists also of limestones and dolomites, and resting on them are shelly limestones of Liassic age, having a thickness altogether of 2000 to 2500 feet. As in the Triassic, there is also in these Rhætic and Liassic rocks a very strong resemblance to the corresponding formations in the Alps, not only as regards the fossils, but in lithological character as well.

There seems to be an unconformity or interruption between the Lias limestones and the next succeeding Spiti shales, which contain Ammonites and other fossils of Middle and Upper Jurassic type.

Resting on the Jurassic Spiti shales there are sandstones and shales with Belemnites probably of Cretaceous age. Above these are light-grey limestones with Upper Cretaceous marine fossils, which are exposed in sections north of the Niti Pass, and in other passes across the watershed between the Ganges and the Sutlej at elevations between 16,000 and 18,000 feet above the sea.

Apparently conformable to the Upper Cretaceous strata, there is on the Húndés high plateau a marine Nummulitic formation much disturbed and altered by igneous rocks, and above this, but unconformably, are sandstones resembling the Siwaliks in character, but without fossils. The sandstones are covered by the horizontally stratified beds of Newer Tertiary age, which form the plain of Húndés, extending 120 miles in length by 15 to 60 miles in breadth, at an elevation of about 15,000 feet above the sea. The sections in the ravines of the Sutlej, nearly 3000 feet deep, show that this plain is composed of boulders, gravel, clay, and mud of all degrees of fineness. The only fossils known from these beds are Mammalian bones, which were at first considered to be of Siwalik age, but Lydekker has shown that they belonged to living genera, and that consequently the deposits are of late Pliocene or even Pleistocene age. Griesbach considers the beds to be of lacustrine origin.

The lines of flexures which form the Himalayas are considered by the author to have existed in Palæozoic times; but the great lateral compressions which pushed up the enormous masses of the Central Asian plateau with its fringing rims of mountains were evidently formed after the deposition of the Miocene beds, since these latter are contorted and crushed, whilst they are covered by the nearly horizontal newer Tertiary deposits, just referred to, which are almost unaltered; consequently the crushing must have taken place between the deposition of the Miocene and Pliocene formations.

In Part II. the author gives a description of some of the principal sections, including those of Painkanda (Garhwál) and the Bhót Maháls of Kumaun, with notes on the Central Himalayas between the Kamet Peak and Spiti. A special feature in this Memoir is the number of excellent figures of natural profiles and ideal sections, the latter constructed on the scale of one mile to an inch both for the vertical and horizontal dimensions. To these are added numerous heliographic reproductions of photographs, taken by the author, which afford realistic pictures of the physical and geological features of the regions described, and they show very clearly the wonderful extent of folding and contortion which the rocks have undergone. It may be said that the value and interest of this report is as much due to the well-known artistic ability of the author as to his capacity as an able geological investigator.

II.—PROCEEDINGS OF THE YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY, Vol. XII. Part I. pages 1–130, with 4 Plates. 8vo. (Halifax, 1892.)

THIS comprises some very interesting and useful papers.

I. T. Hick gives a résumé of the latest information about the growth and structure of the *Calamitæ* from the Coal-measures of Yorkshire.

II. B. Holgate, by means of a very careful examination of 60 beds of the Coal-measures at Leeds (Patent Brickyard, No. 1; Patent Brickyard, No. 2; Boyle's Brickyard; and Gould and Stevenson, Hunslet) finds reasons for indicating the original conditions and mode of origin of the several strata, defining their methods of deposition and their properties. These strata are successively arranged (from below upwards) in a long table (pages 16–21), with (1) their local names; (2) their original constituents, and their included animals and plants; (3) the mode of their formation as deposits; (4) the changes that have taken place in them since their deposition; (5) their present properties and uses; (6) their thicknesses. Thus, taking a series of Mr. Holgate's results in order, it is pointed out that there is indication of (1) a beach: then (2) of dry land of fine siliceous loam: (3) sinking land (with spores, fish-remains, and trees); (4) land still sinking, and the deposit becoming coarser, with the water almost motionless, away from the force of the stream; (5) centre of the stream, water flowing more quickly; (6) direction of river still changing, water with quickening speed; (7) ripple-marks at top, stream changing course and leaving ripple-marks dry; (8) stream again, over dried sandstone, depositing fine white sand, which takes casts of ripple-marks below; (9) centre of stream now at some distance, and water moving gently; (10) water more rapid; (11) water very slow; mud with Anthracosiæ, fish-scales and water-plants; (12) stream quickening, and so on, with ever variable conditions of muds, sands, and coals, with or without Fishes, Anthracosiæ, Lepidostrobi, Stigmariæ, Ferns, Calamites, etc. The salt and mineral waters are referred to; the seat-earths or fire-clays with their included roots and rootlets, are especially noticed (pp. 11–13), with their relation to the trees and plants once rooted in them, and to the coal-beds overlying them. The shales, including the blue, brown, and grey "binds," and the ironstone nodules, some of which yield the "best Yorkshire iron," are also described, both in the Table and at pages 13 and 14.

The evidences of the growth of land and its replacement by water, at this area, usually with river-currents, but once at least forming a lake, with mud full of fishes and molluscs, are interesting, and apparently very judiciously worked out. The chemical action in dissolving and redepositing mineral-salts, and forming concretions and definite nodules are noticed; as well as the effects of lateral thrusts and slidings. Lastly, the appreciations and uses of the several beds, and their measured thicknesses, render this memoir very valuable both to the practical people of Leeds and to geologists in general.

III. C. E. De Rance continues his important researches, with the other members of the Underground Water Committee of the British Association, and here treats of the underground waters in Lincolnshire, as proved by borings at Gainsborough, Worksop, Horncastle (tapping at Woodhall Salim Spring and as shown in the Appendix, pp. 35–51) by the supply from wells and borings in the several geological series of strata, there being about 15 water-bearing horizons, half of which are regarded as good for a public water-supply.

IV. G. R. Vine supplies "Notes on some new little-known Eocene *Polyzoa*," pp. 52–61, mostly from Fareham in Hampshire. The stratum from which Mr. A. Bell obtained them is regarded by him as "a passage-bed between the London Clay and the Bracklesham series." From the Eocene beds of England Mr. Vine here enumerates 8 species of the *Cyclostomata*; and 21 of the *Cheilostomata*; and he describes 3 of the former, and 4 of the latter group.

V. A. S. Woodward, treating of the "Hybodont and Cestaciont Sharks of the Cretaceous Period," first refers to the characteristics of the *Hybodus* of the Lias and other Mesozoic formations, and proceeds to describe in detail some of the special characters well shown in remains of *Hybodus basanus*, collected from the Wealden beds of the Hasting coast by the late Mr. S. H. Beckles, and now in the British Museum. One of the specimens is shown in pl. i. and another in pl. ii. fig. 1. A dorsal fin-spine of *Synechodon* (?) from the Gault, p. 66, is figured in pl. ii. fig. 2. Some characteristic teeth of *Synechodus Illingworthi* (formerly recognized as *Acrodus* or *Hybodus*) are described pp. 66, 67, and figured pl. ii. figs. 1–7. The author considers that *Drepanephorus*, and some Cretaceous teeth known as *Strophodus* and *Acrodus* belong to *Cestracion* or the Port Jackson Shark; and one of these, *Acrodus rugosus*, he here describes and figures, p. 67, pl. ii. fig. 8.

VI. J. E. Bedford directs attention to "Evidences of Glacial Action near Leeds," on the Ganiston beds of the Lower Carboniferous shales and grits quarried at Headingley, in the valley below Meanwood. He notices moraine material of sandy clay, with irregular patches of sand, and containing great quantities of subangular blocks of grit-rock derived from the Ganiston beds. The shales below have also been much bent and crushed. The probable direction and range of the ice are discussed.

VII. J. S. Tute describes a limestone conglomerate of Permian age at Markington, and a section of Permian beds near Wormald Green.

VIII. G. R. Vine describes (pp. 74–92), and figures in plates iii. and iv. some peculiar Palæozoic Polyozoa, belonging to the genera:—1. *Vinella*, Ulrich; 1 species and variety: 2. *Ascodictyon*, Nicholson and Etheridge, jun.; 7 species: 3. *Rhopalonaria*; 2 species. These appear to be Ctenostamatous *Polyzoa* and early representatives of the Stoloniferous *Vesicularidæ*, or possibly of the *Eutoprocta*. The late Mr. Busk noted that Mr. Vine was the first to indicate this alliance and Mr. Ulrich accepted it, and added the genus *Vinella* to the group. They belong to the Silurian, Devonian, and Carboniferous formations of Britain and America. They consist of creeping or attached stolon-like threads, with numerous vesicles (cells? or zoœcia?), and plate iv. illustrates *Ascodictyum siluriense* and the recent *Valkeria tuberosa* together for comparison of the fossil and recent forms.

IX. R. Reynolds illustrates by diagram the Intense Rainfall at Leeds on July 19th, 1891.

X. J. Spencer, proving "the Affinity of *Dadoxylon* to *Cordaites*," observes (p. 104) that "so long as *Dadoxylon* was regarded as a true Pine, it appears to afford a strong argument against the theory of evolution; but now that it has been shown that its supposed affinity with the Pines is based entirely upon the resemblance of its wood to that of the Araucaria, the structure of the whole stem, pith, wood, and bark being taken into consideration, it is seen to have more affinity with the Cycads as seen in *Cycas revoluta*, than with *Araucaria*, and it is found to occupy its natural place both in the vegetable kingdom, and in the order of its appearance in geological time, according to the theory of evolution."

XI. E. Jones details the circumstance of the further examinations of the Elbolton Cave, and states that continued exploration is required.

XII. A bibliography of memoirs relating to the geology of Yorkshire for 1889–90 is appended at pages 119–122. T. R. J.

REPORTS AND PROCEDINGS.

◆

Geological Society of London.

I.—April 27th, 1892.—Prof. J. W. Judd, F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "Notes on the Geology of the Northern Etbai or Eastern Desert of Egypt; with an Account of the Emerald Mines." By Ernest A. Floyer, Esq., F.G.S.

The principal feature in the district is a long ridge of igneous upthrust running N.N.W. and S.S.E., in which porphyry rises into lofty peaks, whilst the lower parts are formed of granites and sedimentary rocks. To the west of the watershed, sedimentary rocks occur dipping slightly to the west.

The following succession of rocks in descending order is given by the author:—Limestone, sandstone, clay, 'cataract'-rock (corresponding to the *Stock-granit* of Walther), and compact hard granite. The sedimentary rocks are frequently metamorphosed, and the author states that every stage of metamorphism is shown, from sandstone to compact green granite. The blue clay shows various kinds of metamorphism, and forms the pistachio-breccia containing topazes, and the mica-schist, mica-slate, and talcose blue clay of the mass of Zabbara containing emeralds.

The author discusses certain theoretical questions, and considers that the erosion of the valleys does not indicate the existence of a greater rainfall than the present one. He concludes by giving an account of the emerald mines.

2. "The Rise and Fall of Lake Tanganyika." By Alex. Carson, Esq., B.Sc. (Communicated by R. Kidston, Esq., F.R.S.E., F.G.S.)

In this paper attention is called to certain recorded discrepancies concerning the discharge of Tanganyika by the Lukuja. It is suggested that the rise of the lake is due to the blocking-up of the river by vegetation, assisted by silting during the first rains, whilst the fall is produced by the destruction of the barrier formed in this manner.

II.—**May 11th, 1892.**—W. H. Hudleston, Esq., M.A., F.R.S.,—President, in the Chair.—The following communications were read:

1. "On the so-called Gneiss of Carboniferous age at Guttannen (Canton Berne, Switzerland)." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

It is stated by Dr. Heim (Quarterly Journal, vol. xlvi. p. 237) that the stems of *Calamites* have been found at Guttannen in a variety of gneiss, *i.e.* in one of a group of rocks which exactly "resemble true crystalline schists in mode of occurrence. Petrographically they are related to them by passage rocks; at least the line of separation is not easily distinguished. . . . The Palæozoic formations mostly show an intimate tectonic relation to the crystalline schists, and have been converted petrographically into crystalline schists."

The author describes the result of a visit to the section at Guttannen in company with Mr. J. Eccles, F.G.S. (to whom he is greatly indebted for kind assistance), and of his subsequent study of the specimens then collected. The belt of sericitic "phyllites and gneisses," presumably of Carboniferous age, represented on the Swiss geological map (Blatt xiii.) as infolded, at and above Guttannen, in true crystalline gneissoid rocks, is found on examination to consist partly of true gneisses, partly of detrital rocks. The boulder from which the stems in the Berne Museum were obtained belongs to the latter. These rocks sometimes present macroscopically, and occasionally even microscopically, considerable resemblance to true gneisses, but this proves on careful examination to be illusory. They are, like the Torridon Sandstone of Scotland, or the *Grès feldspathique* of Normandy, composed of a detritus of granitoid or gneissoid rock, which sometimes forms a mosiac resembling the original rock, and which has been generally more or less affected by subsequent pressure and the usual secondary mineral changes. Thus, if the term be employed in the ordinary sense, they are no more gneisses than the rocks of Carboniferous age at Vernayaz (Canton Valais) are mica-schists, but in some cases the imitation is unusually good, and, so far as the author saw, there are at Guttannen neither conglomerates nor slates to betray the imposition, as happens at the other locality.

2. "On the Lithophyses in the Obsidian of the Roche Rosse, Lipari." By Prof. Grenville A. J. Cole, F.G.S., and Gerard W. Butler, Esq., B.A., F.G.S.

The rock described in this paper differs in no essential particular from that at Forgia Vecchia, or from the obsidian on the north flank of Vulcano; but the specimens show in a specially striking manner the passage through various stages of lithophysal structure, from indisputable steam-vesicles with glassy walls to typical solid spherulites. A full description is given of the formation of spherulites by a double process—firstly, divergent growth from the margins of vesicles outwards, and, secondly, convergent growth inwards from the margins towards the centres of the hollows, until in the smallest cases the fibres from the opposite sides of the vesicle may meet in the centre, producing a spherulite, which, but for the occurrence of intermediate stages, might be supposed to have originated entirely by divergent growth. The authors give details of the appearances presented by intermediate stages of growth.

The prevailing type of spherulite, both in Lipari and Vulcano, shows in section a dusky fibrous central area, which may possess concentric as well as radial structure, surrounded by an irregular brown cloudy zone of various width. The authors' studies lead them to the conclusion that this type owes its characters to the dual mode of growth, and therefore to the original presence of vesicles in the rock. Commonly the process of infilling does not go so far as this; on the ends of the felspar fibres plates of tridymite are deposited, and this seems to close the growth. It is clear that the lithophysal structure of the Lipari obsidians was formed during the cooling of the mass, and not by subsequent amygdaloidal infilling of vesicles.

The authors discuss the effect of confined vapours on such rocks as those forming the subject of the paper, noting that these vapours may be kept at a high temperature for a considerable time, each vesicle thus becoming a sphere of hydrothermal action; so that if the surrounding glass remains at a temperature little below its fusion-point, crystallization will be promoted in it, and at the same time the action of the vapour in the vesicle will produce reactions on its walls.

An Appendix, by Prof. Cole, treats of the lithophyses and hollow spherulites of altered rocks. While admitting the presence of true lithophyses in many of the Welsh lavas, he is not prepared to abandon a former suggestion that the interspaces between successive coats of the Conway lithophyses result from alteration of a formerly solid mass. In the lavas of Esgair-felen and near the Wrekin he has no doubt as to the production of "hollow spherulites" by ordinary processes of decay. The typical Continental pyromerides are truly spherulitic, as is much of the Wrekin lava. In the latter case and that of the rocks of Bouley Bay it will be difficult to distinguish between infilled primary and secondary cavities.

CORRESPONDENCE.

"THE RECENT ELEVATION OF THE HIMALAYAS."

Sir,—The nummulitic limestones occurring in the Hundes Valley show that in Eocene times the ground where the Himalayas now stand was covered by the sea. This is, I believe, admitted by Dr. Blanford. In the Manual of Indian Geology for which he and Mr. Medlicott are responsible he goes further, and expressly says that "*at the close of the Miocene epoch no such mountain barrier as exists at present separated the Indian peninsula from Central Asia*" (op. cit. p. 585). The opinion of Dr. Blanford in 1878 therefore was that the Himalayas are of *post-Miocene* origin.

The superficial beds which contain the mammalian remains we have been disputing about lie unconformably upon certain speckled sandstones which Griesbach classes as of "Miocene and possibly of later age." Mr. Lydekker, after discussing the remains, says of these mammalian beds, "the beds in question are probably of *Pleistocene age*, and almost certainly not older than Upper Pliocene" (Records, Geol. Surv. India, vol. xiv. p. 181).

General Richard Strachey, who examined them with great care, says of them in his article "Himalaya" in the last edition of the Encyclopædia Britannica, "there is no room for doubt that these deposits have been raised from a comparatively low level to their existing great elevation of upwards of 15,000 feet *since they were laid out*." Mr. Griesbach allows that these beds are everywhere raised up on end as is also the case along the southern margin of the lower hills which are skirted by the Siwaliks (Mems. Geol. Survey of India, xxiii. p. 34).

These facts seem to me to justify my contention that the Himalayas have been largely uplifted since Pliocene times. Mr. Blanford was himself once of the same opinion. When the Manual already quoted was published, namely, in 1878, his view was that the Himalayan elevation took place after the deposition of the Siwalik beds, that is, that it was post-Pliocene. I understand him to say that he has since changed his mind because Mr. Lydekker has shown the Rhinoceros remains found at Hundes to belong to an extinct genus, and he refers me to the Catalogue of Fossil Mammalia in the British Museum, vol. iii. p. 158, where he says I shall find that the Tibetan Rhinoceros was closely allied to a species belonging to *Aceratherium*, a small hornless (extinct) group with well-developed incisors in both jaws, and Dr. Blanford accordingly says very positively that the Rhinoceros in question cannot have been the *R. antiquitatis* as I had conjectured, and implies that the beds in which the remains occur must belong to an older horizon.

I confess, Sir, that his statement surprised me greatly. In the first place I knew that the remains from Hundes comprised no teeth and no skull, and I could not understand on what possible grounds Mr. Lydekker, whose patience and caution are so conspicuous, could have come to such a very definite conclusion about the specific character of the Rhinoceros referred to. As a matter of fact he does nothing of the kind. He expressly says of the remains "*they are not specifically determinable*" (loc. cit.).

In the face of this specific statement, I can neither understand how Dr. Blanford should have attributed to Mr. Lydekker a conclusion for which there seems to be no foundation, and secondly, how he can, because of a mere phantasm, justify to himself and us completely changing his own views on a most critical matter. I am bound to say, apart from everything else, there is a very strong *a priori* improbability that the Rhinoceros remains from Hundes belong to an extinct genus. Mr. Lydekker distinctly says "all the remains found at Hundes, with the doubtful exception of *Hippotherium*, belong to *living* genera," and he treats them as Pleistocene or Pliocene. The genus *Aceratherium* belongs to an older horizon altogether. So far as we know it was a tropical or semitropical genus, and there is no warrant for attributing to it, as Dr. Blanford does, a capacity for living under conditions like those of the Hundes plateau. The only species of Rhinoceros known to me which were the companions of the Horse, etc., etc., elsewhere, were the *R. antiquitatis* and the *R. Merckii*, to one of which I believe the remains probably belonged.

My view in regard to the impossibility of supposing that any species of Rhinoceros could live where the remains are found in Tibet is shared by better authorities than myself. Strachey expressly says that "their existence in the present condition of the Tibetan plateau would be quite impossible," while Dr. Falconer, *facile princeps* as an authority on the Pachydermata recent and fossil, says, "Henry Colebrooke, the first who, along with Colonel Crawford, measured the heights of the Dwalagiri, procured from the plateau of Chauthan in the Himalayas, at a height of 17,000 feet above the sea-level, fossil bones, which were brought down and exported as charms into India, to which the natives attributed a supernatural origin, and called them 'lightning or thunder bones.' At the present time, during eight months in the year, the climate differs in no important respect from that of the Arctic circle, and in the whole of the district there is not a single tree or shrub that grows larger than a little willow about nine inches high. The grasses which grow there are limited in number, and the fodder in the shape of Dicotyledonous plants is equally scarce. Yet, notwithstanding this scantiness of vegetation, large fossils were found of the Rhinoceros, the Horse, the Buffalo, the Antelope, and of several carnivorous animals; the group of fossil faunas as a whole involving the condition that, at no very remote period of time, a plateau in the Himalayan Mountains, now at an elevation exceeding three miles above the level of the sea, where we get the climate of the Arctic regions, had then such a climate as enabled the Rhinoceros and several subtropical forms to exist. . . . . The only rational solution which science can suggest is that within a comparatively modern period, a period closely trenching upon the time when man made his appearance upon the face of the earth, the Himalayas have been thrown up by an increment closely approaching 8,000 or 10,000" (Proc. Roy. Geol. Soc. vol. viii. pp. 41 and 42). I commend this passage to Dr. Blanford.

I had written a detailed criticism of his rejoinder, in which I traversed every point he has made, but I do not think it right to unduly load your pages with an ephemeral polemic, and I have merely therefore selected one issue as a sample, and I venture to think it shows that the position I have supported is unassailable.

HENRY H. HOWORTH.

CONE-IN-CONE STRUCTURE.

SIR,—In reference to the statement of Mr. Alfred Harker, F.G.S., regarding radiation, and inversion of the cone structure, in nodular masses, in May Number of GEOL. MAG., I hope you will kindly allow me to state, that I have in my printed paper, on "Cone-in-one Structure," mentioned in March Number of GEOL. MAG., offered a short explanation, that seems satisfactory to myself, and others, that have seen my specimens,—regarding the radiated and inverted structure of the cones, sometimes seen in nodular masses; this radiation, as stated in paper, pp. 26, 27, being due to secondary causes that had acted on the cone stratum after the cone structure itself had been developed.

I point out in my paper, in the first place, that the cones, in any continuous level stratum, were evidently formed, through the upward escape of gases from below, whilst the stratum itself was being deposited the cones, invariably having their apices directed downwards to the lower part of the bed. In those cone strata where there has been an after-tendency in the sediments to aggregate into nodular masses, these nodules, in their contraction from larger into smaller dimensions, during their solidification, often show clear evidence of the gradual pulling of the cones, from their former erect position, all over the surface of the nodules; they radiating, outwards, from the centre to the circumference, there also being evidence of much crushing and distortion of the cone structure all along their outer edges. I further point out that "where the contraction would be greatest, as in the more argillaceous nodules, there may have been a bending, and in some instances a complete inversion of the cones around the edges of the nodules."

Since my paper was printed, in 1886, I have obtained many other illustrative specimens from our Scottish coal-field. These clearly show that the radiation and inversion of the cones, in nodular masses, was due to after secondary causes, the cone structure being first, the formation of the nodules being second, and the amount of radiation, and inversion of the cones, affords a measure of evidence as to the amount of contraction that has taken place amongst these nodules previous to complete solidification.

HUNTERIAN MUSEUM, UNIVERSITY, GLASGOW.
May 9th, 1892.

JOHN YOUNG.

DISSIPATION OF ENERGY AS A GEOLOGICAL FACTOR.

SIR,—Many readers of the GEOLOGICAL MAGAZINE will, perhaps, be glad to have their attention drawn to to the following passage, which concludes an article by Lord Kelvin (P.R.S.), on "Dissipation of Energy," in the "Fortnightly Review" for March, 1892:—

"The whole store of energy now in the sun, whether of actual heat, corresponding to the sun's high temperature, or of potential energy (as of a not run-down weight of clockwork)—potential energy of gravitation depending on the extent of future shrinkage which the sun is destined to experience, is essentially finite; and there is much less of it now than there was three hundred thousand years ago. Similar considerations of action on a vastly smaller scale are, of course, applicable to terrestrial plutonic energy, and thoroughly dispose of the *terrestrial 'perpetual motion,'* by which Lyell and other followers of Hutton, on as sound principles as those of the humblest mechanical perpetual-motionist, tried to find that the earth can go on for ever as it is, illuminated by the sun from infinity of time past to infinity of time future, always a habitation for race after race of plants and animals, built on the ruins of the habitations of preceding races of plants and animals. The doctrine of the 'Dissipation of Energy' forces upon us the conclusion that within a finite period of time past the earth must have been, and within a finite period of time to come must again be, unfit for the habitation of man as at present constituted, unless operations have been, and are to be, performed, which are impossible under the laws governing the known operations going on at present in the material world."

There can be no necessity for pointing out the importance of this *dictum* from the pen of Lord Kelvin; it supports my own contention in the Geological Magazine of July and October, 1891 (pp. 300 and 479-80). I will not intrude upon your space by reiterating what I have already put into print, but I trust you will, with your usual courtesy, allow me to refer the reader to such passages as are to be found in my little work.[1] In the light of what I have quoted above from Lord Kelvin it can scarcely be said that I spoke too strongly in animadversion on the Huttonian School, in the concluding paragraph of my "Note on the Airolo Schists Controversy" in 1890 (See Geol. Mag. Dec. III. Vol. VII. p. 259).

The concluding paragraph of Sir A. Geikie's Presidential Address to the Geological Society for 1892 shows how opinion is veering at the present moment; and during the present session two papers of importance have appeared, one by Professor Bonney and Gen. MacMahon, another by Messrs. Dakins and Teall, in which attempts have been made to work out the history of the structural phenomena observable in igneous masses of particular areas on principles applicable to an universal magma, at a period of the Earth's history when the energy since dissipated by radiation into space was concentrated in the lithosphere. A great deal of what the writers referred to have now put forward was seen more than forty years ago by that sagacious geologist, the late Prof. John Phillips, F.R.S., as applicable to the crystalline rocks of the Malvern range (see Mem. Geol. Survey, vol. ii. part 1), which he saw, with an insight not befogged by the later mists of "regional metamorphism," to be in the main a truly igneous series. On the Malvern Crystallines I hope, after ten weeks' hammering at them, to have more to say anon.

A. Irving.

Wellington College, Berks,
11*th May*, 1892.

EARTHQUAKE SOUNDS.

Sir,—There are one or two points in Mr. C. Davison's paper on earth-quake-sounds I should like to draw attention to.

In most Italian tectonic earthquakes, the sound phenomena precede the mechanical disturbances, though the former overlap the latter the nearer the epicentrum is approached. This means that eir production is almost simultaneous, but the smaller sound ibrations travel at a greater rate than the larger mechanical ones.

---

[1] "Metamorphism of Rocks" (London, 1889), see pp. 18, 19, 22, 23, 70, 71, 94, 95, and 96.

The fact that the more destructive the earthquake, the less marked roportionally is the intensity of the sounds is easily explicable. he sound vibrations are more quickly used up in traversing a given ickness of rock, whilst the mechanical vibrations have hardly been fluenced in the short distance travelled in the shallow focussed ocks that constitute the majority of the destructive earthquakes. or the same reason of the more rapid destruction of the sound ibrations by the rocks traversed the seismic area of sounds is uch more limited than that of the quakes. It must also be emembered that during destructive earthquakes much of the noise due to cracking and falling buildings, shaking trees, etc.

As to the cause of earthquake-sounds I believe they are very arious in different earthquakes, and even in any one earthquake. r. Davison speaks only of fault friction, but rather neglects the ctual initial fracture, which we should expect would produce a very ud noise. Next comes rock-crushing, such a common phenomenon n any mountain region, especially along the central ridges and roughs of anticlines and synclines. Then again we have to con- ider the fracturing or splitting of rock by the formation of igneous ykes, which may occur in a region free from surface volcanic henomena. Is it possible that the hundreds of dykes that rent the ld rocks of the northern counties of England and Scotland, and ost of which never reached the surface, were not accompanied in heir formation by earthquakes and *earth-sounds*.

The origin of these sounds is no doubt the smaller vibrations roduced by the mechanical disturbances in fracturing and slipping r grating in the tectonic earthquakes. In the case of volcanic or lutonic shocks the sound is in the first place due to splitting and racturing of the solid rocks. It is then followed by the friction f the injected fluid magma, and the sudden sharp arrest of this gainst the walls of the cleft. The phenomenon is very similar to he sounds produced by suddenly pumping water into a collapsed eather hose-pipe, closed at the opposite outlet. We have in such case first a gentle rush followed by a sharp snack as the water s arrested by the fully distended walls. Very similar sound- henomena may be heard on closing sharply a tap through which ater, under considerable pressure, is flowing. There is yet another ource of sound in such earthquakes, and that is the vesiculation of ny aquiferous magma when allowed to expand through a newly ormed fissure just filled by it.[1] All these sounds are practically imultaneously produced, and their combined effect with the pre- ominance of one or another would explain the variable nature of he audible phenomena of an earthquake.

The mechanism of production of earthquake sounds I fully dis- ussed years ago,[2] whilst experimental researches on this question have been published not long since by Italian investigators, who have shown the conclusions arrived at by myself and others were correct, that sound-waves travel faster than the coarser mechanical vibrations when traversing most rocks.

---

[1] This may possibly explain the boiling cauldron sound so often mentioned in arthquake descriptions.

[2] See my monograph of the Earthquakes of Ischia, pp. 82, 89, and Proceed. oy. Soc. Dublin, 1886, pp. 120, 124.

7, Chiatamone, Naples. H. J. Johnston-Lavis.

THE TEMPLE OF JUPITER SERAPIS IN PUTEOLI (POZZUOLI).

Sir,—It is well known that the ruins of this Temple have been looked upon as the most striking example of subsidence in historic times. Although it has taken place within the Christian era, the date has been but vaguely known. Babbage, in his article, Geological Transactions, vol. iii. (1847), mentions an inscription of Alexander Severus on the Temple asserting it to have been adorned by his munificence. As Alexander Severus reigned from A.D. 222 to 235, at that time the Temple must still have have been above sea-level. In Lyell's Principles, vol. ii. p. 173, there is a quotation from Loffrado which proves that in 1530 a great part of the site of modern Pozzuoli of ancient Puteoli, was under water. The city was captured by Alaric A.D. 410; then by Genserie 455; then by Votila 545 (E. H. Bunbury in Smith's Dict. Geog. art. Puteoli); but we have no information as to whether the Serapeum was then above or under water. The Temple of Serapis then was above water in 230 and below water 1530, and during the intervening 1300 years there seems no reliable information.

However, in the *Acta Reta et Pauli*, Greek forms, dating according to Lipsius from the fifth century, we have the following passage—I quote from Walker's Translation Ante-Nicene Library, vol. xvi. p. 258:—"And Paul being in Ponteole (Puteoli) and having heard that Dioscorus had been beheaded, being grieved with great grief gazing into the night of Heaven said 'Oh Lord Almighty . . . . punish this city and bring out of it all who have believed in God and followed His word.' He said to them therefore 'follow me.' And going forth from Pontiole they came to a place called Baias (Baiae) and looking up with their eyes they all see that city Pontiole sink into sea-shore (*εἰς τὴν ὄχθαν τῆς θαλάσσγς*) about one fathom (*ὡσεὶ ὀργυίαν μίαν*) and there it is until this day for a remembrance under the sea." It is evident that when the Greek of the *Acta Petri et Pauli* was written Pozzuoli was under water, as it was in the days of Loffredo (though perhaps not so deeply submerged), and had been so for so long that the memory of the subsidence and the circumstances attending it had been utterly lost. If we allow a century to have been sufficient to have caused this utter oblivion, we have then reduced the 1300 years to about 150. In other words somewhere between the middle of the third century and the middle of the fourth this event must have occurred. The phrase "into the sea-shore" (*εἰς τὴν ὄχθαν τῆς θαλάσσης*) supports Babbage's theory that the Temple first sank in a lake of brackish water. This is confirmed by the assertion that the city sank a fathom (*ὡσεὶ ὀργυίαν μίαν*). J. E. H. Thomson.

10, Allen Park, Stirling.

OBITUARY.

WILLIAM REED, M.R.C.S. (ENGL.), F.G.S., Etc.

Born 1810. Died 1892.

By the death of Mr. William Reed, of Blake Street, York, the orkshire Philosophical Society has lost one of its oldest members, nd certainly—as regards its Museum—one of its most liberal enefactors.

Mr. Reed commenced life as pupil of Mr. Ness, surgeon, Helmsley, nd it was probably during his residence in that district that he cquired that strong affection for the study of geology which haracterized his later years, and gave him a place amongst the first eologists of the past half century. Upon leaving Helmsley he ntered St. George's Hospital, London, and subsequently continued is studies at Paris. In the year 1837 he qualified as licentiate of he Society of Apothecaries, and the following year he took his egree as member of the Royal College of Surgeons (Engl.). He as afterwards appointed resident medical officer of the York County ospital, and surgeon of the York Eye Institution, founded by Mr. enry Russell. After occupying these positions for some years, to he great benefit of the patients under his care, he removed from ork to Foston, and there carried on a private practice with marked uccess for several years. Afterwards he again took up his residence n York, and remained there during the rest of his life. In York e entered into partnership with Mr. Benjamin Dodsworth, who at hat time enjoyed a very extensive practice, and the partnership ontinued several years. After leaving his partner Mr. Reed carried n practice for some years alone. This practice, owing to his great iligence and professional skill, became very extensive, so much o, indeed, that he found it necessary to take a partner, and he as joined by Mr. Rose, with whom he worked until nine or ten ears ago, when Mr. Reed retired from the profession. Since that ime he has devoted his leisure to the study of geology, to which great portion of his earlier leisure time had also been given. any years ago he became connected with the Yorkshire Philoophical Society, and it is to him more than to any other person hat the Museum at York owes its present high standing. His hole soul was devoted to the science of geology, and the excellent ollections of specimens now to be seen in the Museum will cause is name to be handed down to many future generations, and ill testify to his great liberality. For many years he has coninually been adding geological specimens to the Museum, but his iberality is most apparent in the two collections of specimens hich he presented, which have raised the Museum to the first osition in the country. The first of these collections was presented n 1878. It contained about 100,000 geological specimens collected y Mr. Reed himself. The following is an extract from the Yorkhire Philosophical Society's annual report:—"In the Geological epartment, the Council have formally to announce the presentation to the Society of the valuable geological collection of their respected Vice-President, William Reed, Esq., F.G.S. The collection presented by Mr. Reed has been formed at a great cost over a period of many years, and has been well known to geologists as one of the most valuable private collections in the United Kingdom. The Council congratulate the Society on its possession, as tending to raise the Museum to the first rank among similar scientific Institutions in this country."

The collection presented by Mr. Reed consists of:—1. A complete set of shells of the land, freshwater, and marine mollusca of Great Britain, comprising several forms first ascertained to be still living members of the British Fauna during the dredging expedition of the "Lightning" and "Porcupine." 2. An extensive collection of mammalian remains from English Post-Tertiary deposits, remarkable among which, for their fine state of preservation, are the teeth and bones of Rhinoceros, Horse, Hippopotamus, Urus, Megaceros, Elephant, Bear, Lion, Hyæna, Beaver, etc. 3. A large series of shells of the same period, from fluviatile and marine deposits, in various parts of England, Scotland, and Ireland. 4. A magnificent collection of fossils from the Norwich and Coralline Crags. The suite of vertebrate remains, especially, is of great value. This is probably the finest private collection of Crag fossils in England, and it is doubtful whether it can be equalled in any of our great public museums. 5. A fine series of plant remains from the beds of Bovey Tracey, Mull, and Antrim. A collection of Miocene shells from the neighbourhood of Bordeaux and Cannes. 6. A large collection of Eocene fossils in a beautiful state of preservation, in which the several subdivisions of the deposits of that period in England are fully represented. 7. An extensive assemblage of fossils from the Chalk, Greensand, Gault, Neocomian, and Wealden. 8. A very large and valuable series of Jurassic fossils. 9. A series of British Palæozoic fossils, especially rich in Carboniferous limestone fossils from the neighbourhood of Settle (upwards of 200 species). A most important feature from a scientific point of view in Mr. Reed's collection is the great care which has been taken to indicate, by labels, the exact locality from which the several specimens have been obtained, so that thorough reliance may be placed on them.

In December, 1880, Mr. Reed made a second presentation to the Society. This consisted of a collection of specimens formed by the late Mr. Edward Wood, F.G.S., of Richmond, Yorkshire, and since known as the "Wood Collection." This, although by no means equal to the one previously presented, is yet a collection of great value to geologists, being particularly rich in Yorkshire fossils. Four great collections had up to that date been formed in Yorkshire during the last half century—namely, those of Mr. Bean and Mr. Leckenby, of Scarborough; Mr. Wood, of Richmond; and Mr. Reed, of York. Of these, a considerable portion of Mr. Bean's fossils were purchased by the Yorkshire Philosophical Society in 1860 for £200, and two of the other collections—Mr. Wood's and Mr. Reed's—have by the public-spiritedness and liberality of the last-named gentleman found their place in York Museum. The Leckenby collection is now in the Cambridge Museum. Mr. Edward Wood had his home among the hills of North-west Yorkshire, and from the Mountain Limestone and contiguous strata of that district he formed the collection which, added to that formerly presented to the Museum by Mr. Reed, raised that Museum to a high position among the geological museums of this country. The Society is greatly indebted to Mr. W. Reed for his presentation of these valuable collections, and also for the able service which for two years he rendered as honorary curator in the arrangement of the collections.

Mr. W. Keeping, M.A., a former keeper of the Museum, read a paper at the monthly meeting of the Yorkshire Philosophical Society held in January, 1881, upon the "Wood Collection." In it he says: —The collection of fossils formed by the late Mr. Edward Wood, F.G.S., of Richmond, Yorkshire, is the result of the constant attention and labour of more than 30 years of his lifetime. Living in a district rich in some of the most beautiful and attractive of fossil organic remains, and impelled by a strong natural love for palæontology, Mr. Wood became an ardent collector of all specimens of geological interest, and such was his success that he ultimately became distinguished as the possessor of one of the finest private geological collections in Britain. Naturally this collection is particularly rich in objects from the Yorkshire dales, especially his own dale, Swaledale: but it also includes collections from many other British localities which were obtained by the help of his many scientific friends and acquaintances, in his own travels, or by his own purchases. Thus the collection came to spread over a wide area both in space and time, forming a fair representation of the whole of the geological periods, but specially rich and valuable in certain formations. To the York Museum this collection is particularly valuable, for it is precisely where we were poor that we here find the greatest riches. It was in the Permian, Coal-measures, the Carboniferous Limestone, and the Old Red Sandstone that our collection, including Mr. Reed's original museum, was weakest; while in the Edward Wood collection these groups are most perfectly represented. Mr. W. Reed, F.G.S., our honorary Curator of geology, was already acquainted with Mr. Wood's collection, and knew how important an addition it would be to the Society's Museum, and he therefore, as soon as the way to its acquisition was open to him, at once decided to purchase the collection and present it to the Society. As a private collection of Carboniferous Limestone fossils Mr. Wood's museum has never been equalled in England, and the other groups of the Upper Palæozoic rocks are also particularly fine. It is without doubt in the Carboniferous Echinoderms, especially the Crinoids, that the collection is most remarkable, and it is best known to geologists as containing a magnificent series of those Crinoids or "Sea Lilies" named in honour of their discoverer, *Woodocrinus*. Some hundreds of specimens of this beautiful fossil were obtained by Mr. Wood, the duplicates being liberally distributed throughout the various Museums of Europe, while some 80 slabs, including all the more choice examples, remain in the collection. Many of the slabs include several heads, some of them exhibiting as many as nine distinct individuals, so that we have altogether a perfect forest of these beautiful sea lilies. The spot where these were found is in a quarry at Lymmas House, Holgate, near Marske, a place in Swaledale, some 13 miles from Richmond, and rather difficult of access. They have not to my knowledge been found in any other locality. Altogether the collection numbers over 10,000 specimens; there being, according to a catalogue made by Dr. Henry Woodward, 9365 selected specimens in the cabinets.

Mr. Reed was of a retiring disposition, and took little interest in public affairs. He was, however, of a genial disposition, and in private life was a pleasant companion.

He never married and lived an extremely abstemious life, performing many acts of private charity and benevolence which the world saw not. He suffered a long time from bronchitis, and about ten days before his death he received a chill which brought on his old complaint, to which he succumbed on Monday the 9th of May at the advanced age of eighty-two years.

Mr. Reed's death will be sincerely mourned by many friends, his loss to the city of York will be great, but to the Yorkshire Philosophical Society still greater.—*Yorkshire Herald*, May 10, 1892.

MISCELLANEOUS.

Major John Plant, F.G.S.

The fact that Major Plant is about to sever his long connexion of forty-two years with the Peel Park Museum, Salford, affords us a welcome opportunity of giving a brief sketch of the life and work of one to whom naturalists and the general public of Salford owe so much, and whose long services the Museum Committee recently recognized by a gratifying tribute.

Major Plant is the son of the late Mr. Robert Fisher Plant, a stationer of Leicester, in which town he was born in October, 1819. At an early age he entered the National School of his native town, and there acquired the rudiments of a sound education, side by side with the Right Hon. A. J. Mundella. On leaving that school, he continued his studies at the Mechanics' Institution, displaying considerable taste for drawing and Natural Science. It was intended that he should adopt the medical profession, and with that view he was articled to a surgeon of Leicester, Mr. T. Paget, but it was afterwards found necessary for him to abandon this pursuit, to assist in his father's growing business. In 1844, he was elected Honorary Secretary of the Leicester Naturalists' Club, and shortly afterwards was appointed Curator of a small museum which had been founded in the town through the instrumentality of the Literary and Philosophical Society. By this time Mr. Plant had obtained that keen predilection for geology which has characterized him all his life; and it was also in 1844 that he read before the British Association, at Birmingham, a paper on "The Discovery of Fossiliferous Keuper Sandstones at Leicester," which were thenceforth included as a distinct stratum in the maps of the Geological Survey.

Doubtless, this scientific taste was fostered by the favourable opportunities offered for geological work in the neighbouring classic area of Charnwood Forest, which presents enigmas yet awaiting satisfactory solution. In addition to his scientific pursuits, he found time to cultivate a knowledge of the fine arts, attaining to some skill in drawing under his friend, the late Mr. B. R. Haydon. In 1846, he was appointed Secretary and Librarian of the Permanent Library, Leicester, where he re-arranged and catalogued 10,000 volumes; and in October, 1849, he became Curator and Chief Librarian of the Peel Park Museum, in which connexion his labours have become so widely known. The story of the Peel Park Museum, which, since the opening in 1849, has gradually grown to be one of the largest establishments of its kind in the country, is also the story of Mr. Plant. Under his direction, and with the aid of generous munificence, it has developed into one of the principal attractions of the busy centre to which it belongs. The library now contains some 60,000 volumes, in place of the 5000 with which it started, and is provided with a handsome reading room. The rooms in which the scientific exhibits are displayed are numerous and well adapted to their purposes; while the art galleries include the great Langworthy Gallery, occupied with marble statues and fine oil paintings of the modern English and French schools. Mr. Plant's varied training had specially fitted him for the management of an institution of such complex character; and now, in its enlarged proportions, altogether beyond the satisfactory control of any one man, there is abundant evidence of his extensive knowledge and skill—signs which only the educated eye can appreciate at their full meaning.

It is, however, principally to Geology and Palæontology that Mr. Plant has given his attention. In 1851 he became a member of the Manchester Geological Society, of which he is now the oldest living member; and in 1864 he was elected a Fellow of the Geological Society of London. About 1870, he began to make a special study of the Coal-measure Fishes in the neighbourhood of Manchester, and his extensive collection has formed the basis of important researches by Dr. R. H. Traquair, of Edinburgh. Several of the species have been named after Mr. Plant. In the Geology of North Wales he has for many years taken a deep interest, especially in the Cambrian fossils found in the locality of Dolgelly. The whole of his collection from this district has been formed under circumstances which make the specimens almost unique, and a selection of the typical forms has been deposited in the British Museum. The type specimen of *Olenus Planti*, named by Mr. Salter and also described by Professor M'Coy in Sedgwick's Catalogue of the Woodwardian Museum, Cambridge, is included in the series. We understand that Mr. Plant is still engaged on researches in the Geology of the South West Coast of Anglesea, the progress of which will be greatly facilitated by his residence in that island, where he now intends to take up his permanent abode, and whither he has for the last twenty-five years resorted for his annual holiday.

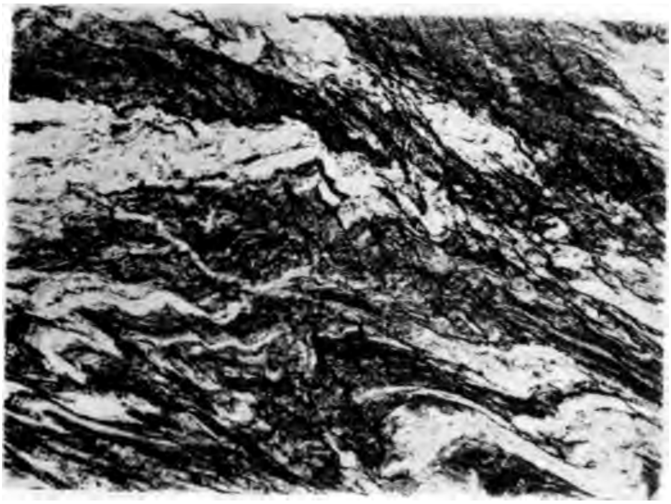
Although now in his 73rd year, Mr. Plant bears but little appearance of his advanced age, and in spite of this and a serious fall which he experienced some fourteen months ago, he still retains the ruddy complexion, robustness of body, and cheerful *bonhomie* which have always characterized him. The limits of space prevent our saying more, beyond recording that Mr. Plant has been a member of the 3rd L.R.F., or Salford Corps of Volunteers, since 1859, and in this he now holds the rank of major. He is not the only member of his family who has devoted himself to scientific pursuits, his eldest brother, Mr. James Plant, being the well-known geologist of Leicester, while another brother, Francis, passed some five years in the active investigation of the natural history of Madagascar, where he died a victim to smallpox. Another brother, Nathaniel, also distinguished himself still more by his geological researches, of sixteen years' duration, in Brazil, including the exploration of the Candiota Coal-fields, made on behalf of the Brazilian Government.[1]

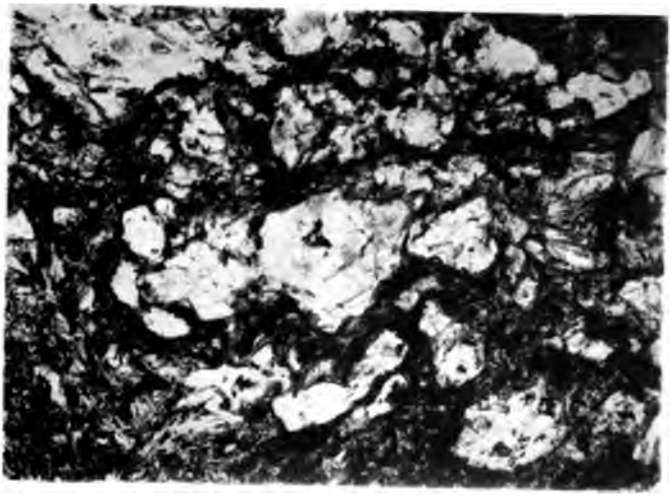
BIRTH OF A NEW SCIENTIFIC SOCIETY.—The New Institute of Mining and Metallurgy, which already numbers more than 100 Members and Associates, recently held its Inaugural Meeting in the Theatre of the Museum of Practical Geology, Jermyn Street, under the Presidency of George Seymour, Esq., A.R.S.M., M.Inst.C.E., F.G.S., ably supported by the leading members of the Mining and Metallurgical profession. The President delivered a most able address, and later in the evening the members and their friends supped at the "Criterion," where speeches were delivered, Mr. F. W. Rudler, F.G.S., making a most brilliant address. We wish the new Society every possible success and prosperity.

---

[1] See GEOL. MAG. Vol. VI. 1869, pp. 147-156, Pls. V.-VI. with description of the Plants by William Carruthers, F.R.S.

1





2

To Illustrate Mr. Hunt's Paper on the Rocks of South Devon.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. IX.

No. VI.—JULY, 1892.

ORIGINAL ARTICLES.

I.—On Certain Affinities Between the Devonian Rocks of South Devon and the Metamorphic Schists.

(Part II.)

By A. R. Hunt, M.A.

(*Continued from page* 247.)

(PLATE VIII.)

The Metamorphic Green Rocks and Devonian Volcanics.

In comparing the quartz-schists with the Devonian sandstones, or grit-bands, several original minerals can be traced from the one to the other, *e.g.* tourmaline, mica, and at least two quartzes. In the case of the Green Rocks and Devonian Volcanics we are met at the outset with the difficulty, that not a grain or crystal of an original mineral has been recorded with confidence as occurring in the metamorphic Green Rocks; though there seems to be little doubt that the latter are often metamorphosed diabases.

The metamorphic Green Rocks seem to be exclusively composed of secondary minerals, of which felspar, hornblende both fibrous and compact, chlorite, and epidote, are the most important.

The Devonian Volcanics, when hard enough for slicing, are for the most part diabases, in which secondary felspar, the two hornblendes, epidote, and chlorite, are here and there developed, to a greater or less extent, by chemical or dynamic action, or by both combined. Microscopic research is thus necessarily limited to the above secondary minerals.

The relation of the Devonian Volcanics to the sedimentary rocks, the relation of the metamorphic green rocks to the mica-schists, and the relation of the Devonian rocks to the metamorphic rocks, from the stratigraphical point of view, form no part of the present inquiry. Suffice it to say that from the latitude of Dartmouth to Torcross, diabases of Devonian age occur here and there striking roughly east and west; and that on crossing the metamorphic border-land we find the place of these diabases taken by green rocks of disputed age.[1]

Within the limits of Dartmouth Harbour and Range we may notice three types of diabase. A porphyritic diabase occurs at

---

[1] Maps indicating the lines of strike of certain of the Diabases and Green Rocks were exhibited by Mr. W. A. E. Ussher in Section C at the Cardiff Meeting of the British Association, 1891.

Sandquay. The western Blackstone is composed of a fine-grained diabase; while a coarsely crystallized diabase forms the southern and larger portion of the islet known as the Mewstone. The Mewstone rock, or one much like it, appears on the coast between Dartmouth and Blackpool Sands, and again further west inland. The Blackstone (western) rock re-appears in Blackpool Valley in a schistose form, where it resembles a schistose rock occurring between Modbury and Aveton Giffard; while a porphyritic diabase, recalling Sandquay, occurs in the Torcross line, near East Charleton. This variety among the diabases is well matched among the metamorphic green rocks, where at one place we may meet with a fine-grained hornblende schist; at another, a rock in which layers of felspar are the most conspicuous feature; or, in which granular felspar is embedded in a matrix chiefly composed of chlorite; or, in which the felspar grains rest in a matrix in which fibrous hornblende is prominent.

In a quarry of greenstone, west of Winslade, a quarried block was seen to be composed of two distinct rocks closely united; one a pale greyish-green diabase, the other a much darker and more schistose rock which recalled some of the green metamorphic rocks further south, *e.g.* at Bickerton. They will be described as Winslade A (No. 38) and Winslade B (No. 39). In A the original augite crystals are well represented; in B it is doubtful whether any can be recognized. In B there is abundance of green typical chlorite, polarizing a deep blue; in A there is a corresponding mineral of the faintest tinge of green, which Mr. Teall informs me is also probably chlorite. The frequent association and intimate mixture of hornblende and chlorite in both the diabases and metamorphic rocks is noticeable.

It is not difficult to trace the two hornblendes and chlorite from the diabases into the metamorphic rocks. In a vein in the Sandquay diabase (a rock in which the original minerals are nearly obliterated) we have secondary felspar associated with fibrous hornblende and very pale chlorite. At Blackpool, chlorite is intimately associated with compact hornblende. At Winslade we have an occasional crystal of compact hornblende and much chlorite in company with a few streaks of fibrous hornblende. Near Start Point we meet with a highly felspathic green rock of gneissoid character containing compact hornblende, much fibrous hornblende, and chlorite. This rock is an epitome of the decomposition products of the Sandquay and Blackpool valley rocks, the fibrous hornblende and secondary felspar of the one, with the compact hornblende of the other, and the chlorite of both, being all represented near the Start.

An interesting feature in the metamorphic green-rocks is the frequent occurrence of rounded granules of felspar full of greenish belonites (actinolite?) in a matrix of what appears to be chlorite and hornblende in varying proportions. In specimens from near Bickerton, both north and south of the valley, as also in one from Rickham Sands, the matrix is chiefly chlorite; whereas in another from near West Bolbury in which the felspar is less conspicuously rounded the matrix contains much fibrous hornblende. The belonites in felspar are such a prominent feature in these rocks that I have carefully searched the more chloritic of the Devonian diabases for any indication of the incipient formation of such microliths in felspar, but hitherto without success. In the more altered Winslade rock, B, there are several clear grains with belonites; but, on comparing this slide with the one from Rickham Sands, Mr. Teall considered the grains in the diabase to be quartz, but was unable to detect quartz in the metamorphic rock; twelve grains taken at random proving to be in each case felspar.

Professor Bonney has, however, described quartz with belonites from the Prawle district, associated with a mineral supposed to be kyanite[1] (Q.J.G.S., vol. xl. p. 17). Miss Raisin has also described "a typical slide of chlorite schist," as containing grains with belonites, the grains being attributed to quartz (Q.J.G.S., vol. xliii. p. 719).

My evidence on this point is merely negative. Quartz grains with belonites appear to be absent from my slides of the green rocks, the water-clear grains being felspar. If such quartz-grains do occur, and we have the evidence of Prof. Bonney and Miss Raisin that they do, it is possible that the early stage of their formation may be revealed in the Winslade Devonian diabase referred to above.

FELSPAR AND FELSPATHIC VEINS.

In 1839 Sir Henry de la Beche reported the occurrence of gneiss near the Prawle Point, by the addition of felspar to the mica and quartz of the ordinary schist.[2] This statement has been the source of much perplexity to geologists. In 1881 the late Mr. E. B. Tawney declared, "there was nothing approaching gneiss there."[3] In 1883 Prof. Bonney suggested that a mica-schist banded with thin *quartzose* laminæ might be De la Beche's gneiss.[4] In 1891 Mr. W. A. E. Ussher called attention to a grey rock near the Start with incipient foliation, presenting a slightly gneissoid appearance.[5] Messrs. Sedgwick, Murchison and Pengelly have each in turn expressed their doubts as to the occurrence of gneiss near the Prawle.[6]

Sir Henry de la Beche defines precisely the rock he considers gneiss, viz. a rock composed of mica quartz and felspar. Thus Prof. Bonney's quartz-schist will not meet the case for lack of felspar, just as the grey gneissoid rock near the Start[7] must fail for lack of quartz.

The importance of De la Beche's observation consists in the recognition of felspar in the mica- and quartz-schists. This felspar occurs either as laminæ in the schists, or as veins, the latter being sometimes associated with quartz and chlorite.

---

[1] I regret to say that my own identification of kyanite in the Bolt Schist (Trans. Dev. Assoc. vol. xxi. p. 260) was wrong. I am authoritatively informed that there is no kyanite in any of my slides from that district; the mineral I mistook being probably felspar.

[2] Report Cornwall and Devon, p. 27.

[3] Trans. Dev. Assoc. vol. xxi. p. 469.

[4] Q.J.G.S., vol. xl. p. 7.

[5] Brit. Assoc. Rep. 1891.

[6] Trans. Dev. Assoc. vol. xi. p. 322.

[7] Appendix, slide 40.

I have specimens of felspar veins or infiltrations, from Start Farm, Lannacombe Mill, West Prawle, Rickham Sands, Starrall Bottom, South Down, and Bolbury Down, thus covering the area of the mica and quartz schists nearly from sea to sea. This felspar constitutes an important, even though it be a minor feature, in the petrology of the district.

Veins of felspar, quartz, and chlorite, in association, are not, I believe, common in the Devonian sedimentary rocks: the only locality in which they occur to my own knowledge being on the raised beach platform at Compass Cove outside Dartmouth Harbour, where Devonian sedimentary rocks are in close proximity to diabases both north and south.[1] Here quartz is the predominant mineral, with felspar sparingly intermingled and chlorite still more so.

Sir Henry de la Beche described the Eddystone reef as "a variety of gneiss similar to some occurring near the Prawle Point."[2] Had the veteran geologist written 'West Prawle' or 'East Prawle,' instead of 'the Prawle Point,' there would be little difficulty in the case, as whereas the Prawle Point is in the area of the Green Rocks, the two villages of that name are on the mica-schists. The Eddystone gneiss has many points in common with the felspathic mica-schists, but very few with the Green Rocks. For instance in a slide of mica-schist from near the Bolt Signal Station we find quartz with minute bubbles, white mica, felspar, chlorite, and garnet. All these minerals reappear in the Eddystone gneiss, with brown mica in addition. All slaty structure has completely vanished, but I scarcely think the Eddystone is more in advance of the Bolt, than the Bolt is ahead of the Start, and the Start of the Devonian micaceous sandstones of Beesands.

Besides the points of general resemblance between the gneiss of the Eddystone and the mica-schist of the Bolt district, it is interesting to note that felspar-quartz veins with chlorite also occur in the Eddystone rock, and were described by Mr. Tawney in 1881.[3]

Two authors have noticed the green decomposition-products of the South Devon greenstones. In 1888 Mr. A. Somervail incidentally observed that both the diabases and green schists were charged with epidotic and chloritic minerals.[4] In 1889 Miss C. A. Raisin demurring to this statement, so far as it affected the diabases, said, that in them she had found chlorite to be "generally rare and often absent;"[5] but records viridite in two specimens, and a variety of palagonite in a third. Further, the authoress distinguishes between the "well-defined" chlorite of the southern rocks and the green mineral of the diabases.

After a careful examination of 28 slides of the schists and diabases I find that 14 out of 16 of the latter contain, in greater or less quantity a pale-green mineral which seems to correspond with Professor Rosenbusch's description of chlorite.

---

[1] Since the above was in type I have been indebted to Mr. Ussher for excellent specimens from the neighbourhood of Bantham.

[2] Rep. Dev. and Cornwall, p. 32.

[3] Trans. Dev. Assoc. vol. xiii. p. 172.

[4] Trans. Devon. Assoc. 1888, p. 224. A rock from Redlap, in Mr. Somervail's collection, is crowded with macroscopic crystals of typical epidote, associated with a little chlorite.

[5] Geol. Mag. 1889, p. 266.

The two remaining diabases are schistose; one, as described by Mr. Harker, contains a chlorite which polarizes in higher tints than usual, and is associated with hornblende.[1] The other, from between Modbury and Aveton Giffard, contains an apple-green chlorite, lying between the laminæ of the rock, strongly pleochroic, which sometimes polarizes the typical blue; sometimes yellow, and sometimes blue with yellow streaks. I have not myself come across any glassy rock or any mineral corresponding with the descriptions of palagonite.

The greater part of the chlorite in the Green Rocks is the strongly dichroic variety, and both in the green rocks and diabases is often associated with hornblende. Ordinary chlorite occurs in the quartz-schists at the Start and Bolt, in some of the felspathic veins, and occasionally in the green schists with the more decidedly dichroic variety. In the diabases, and in the metamorphic rocks and veins, the pale chlorite seems connected with decomposition by chemical action, while the deeper coloured, dichroic and more brightly polarizing variety seems to be closely associated with hornblende, and dynamic alteration.

I must confess to finding the chlorites very difficult. Much of this mineral in one of the diabases, when examined first by lamp light, appeared so completely isotropic that I mistook it for a glass. Even by daylight this chlorite often seems more colourless than usual, more free from any trace of dichroism, and polarizes with tints of the faintest. On the other hand the chlorite of the Schistose Diabases and of the Green Rocks often tends to the other extreme, being deeply coloured, highly dichroic, and polarizes in comparatively bright colours. On referring to those authors who have mentioned the chlorites of South Devon, their descriptions will be seen to be often qualified or guarded, *e.g.* Prof. Bonney—"rather a chlorite than a mica," Q.J.G.S. vol. xl. p. 14, and, "a species of the chlorite group," p. 16. Miss Raisin—"generally dichroic changing from a feeble brownish tint to a deep green colour, Q.J.G.S. vol. xliii. p. 719. and "possibly in part at least prochlorite of Dana, p. 720. Mr. Harker—"apparently one of the ripidolite group," *Appendix, slide No.* 40, and in a letter referring to one of the Devonian Quartz-felspar-chlorite veins, "no doubt one of the chlorite minerals, but I could not with confidence say more." Mr. Tawney, on a felspar vein in the Eddystone gneiss—"vermiform collections of clinochlore" Trans. Devon Assoc. vol. xiii. p. 172.

In describing the schist from the Start Point, Miss Raisin records the following facts, the correct interpretation of which is of crucial importance:—"In all these slides I was on the look out for evidence of secondary cleavage-foliation, and I could trace in all the beginnings of such a structure." In my own investigation of the grits and schists, specimens as free as possible from crumpling have invariably been sought for comparison; and as in these rocks the absence of crumpling proves the absence of lateral pressure, stratification-foliation and cleavage-foliation, if present, are likely to be coincident.

---

[1] Appendix, slide 33.

In the slide described by Mr. Harker[1] it will be observed that the little cracks cemented by opaque iron-ores maintain a rough parallelism, agreeing in direction with the scales of mica. The hand-specimen shows also the general parallelism of the quartz-laminæ. This rock is clearly a modified micaceous grit-band in which all the minerals, iron, quartz, and mica, tend to lie in planes parallel with the original bedding of the band.

Now if we turn to an equally uncrumpled Devonian micaceous grit, we find a rock macroscopically extremely like the quartz-schist, with well-defined lines of sedimentation in which the iron-ores and minute flakes of mica as seen in the microscope take a decided linear arrangement; the whole rock being also micaceous. Sometimes these Devonian grits, through pressure, crack and gape in the planes of stratification, sometimes obliquely across these planes; such cracks being occasionally filled by quartz, without the grit itself being affected by solution. Now if these grit bands with their already existing iron- and mica-lines were exposed to sufficient heat and pressure for their constituent quartz-grains to be dissolved, the mica-flakes distributed through the rock would necessarily float out into the quartz, and the two together would fill and cement cracks dependent in direction on the direction of pressure; so that these new cracks would (in the majority of cases) not be parallel with the original stratification-foliation of the grit. This simple process seems to be indicated in the less altered quartz-schists of the Start, in which to judge by analogy with the Devonian grits the black lines of iron and mica usually correspond with the original sedimentary lines, while the quartzose laminæ are in nearly all cases of subsequent date.

It may be noted that among the minerals accompanying and determining foliation in the mica- and quartz-schists of South Devon are iron, mica, quartz, and felspar, and in the green rocks felspar, hornblende, and chlorite. In the Devonian Volcanics the laminæ of the schistose rocks are often determined by hornblende and chlorite, but I have not noticed any distinct alineation of felspar, as distinguished from veins.

EXPLANATION OF PLATE VIII.

FIG. 1.—Red Mica Schist, north of Start Signal House. (24) Magnified 13 diameters. Original streaks of red and black iron ores traverse the slide in places obliquely from top to bottom. These are intimately associated with mica, which lies between them in wavy lines. These more ancient minerals are invaded by quartz, which traverses the slide from side to side. The mica-flakes disengaged by the quartz tend to align themselves flake by flake in the general direction of the quartz. In this rock, though a mica schist, the planes of schistosity are indicated by iron and quartz, the direction of the mica being uncertain.

FIG. 2.—Chlorite-schist, Rickham Sands, Salcombe. Magnified 31 diameters. Secondary felspar-granules with belonites in a chloritic matrix. The schistose character of the rock is determined by the general alignment of the felspar-granules.

(*To be continued in our next Number.*)

---

[1] Appendix, slide No. 8.

II.—NOTES ON THE CONISTON LIMESTONE SERIES.

By J. G. GOODCHILD, F.G.S.,

H.M. Geological Survey.

Communicated by permission of the Director for Great Britain.

MR. MARR'S valuable communication on the Coniston Limestone Series, which appeared in the March Number of this MAGAZINE, is sure to be welcomed as an excellent summary of the geology of this interesting group of rocks. It contains a digest of most of the published work relating to the Coniston Limestone Series, and also many new facts and arguments drawn from Mr. Marr's own observations in the field.

The stratigraphy of some of the areas referred to in the paper presents very considerable difficulties, and therefore requires very detailed observations before any definite conclusion can be drawn from the facts. This is perhaps the reason why so many observers have differed in their interpretation of the evidence. In the areas adjoining the Pennine-Craven Fault especially the geology is so complicated that many square miles of country might be described as consisting of a gigantic fault-breccia, whose constituents appear to defy any attempt at identification. The officers of the Geological Survey had to go over a large part of this faulted area again and again, long after every available piece of evidence within the area itself appeared to be exhausted. All this requires much time. But one result of such repeated revisions of the more difficult parts is that those who have gone so many times over the ground gain obvious advantages over those who happen to be less fortunate in such matters.

Under the circumstances, therefore, Mr. Marr will hardly be unprepared to find that, in minor points of detail relating to the rocks under notice, some of his predecessors have arrived at conclusions different from his own. That is so in the present case; and I avail myself of the Director's permission to call Mr. Marr's attention to one or two such, in the hope that the corrections may be of service to him in his future work over the same ground.

The Bala Rocks of the Cross Fell Inlier.—The highest members of this series have already been adequately described by Messrs. Marr and Nicholson (Q.J.G.S. vol. xlvii.), so that there is no need to discuss any special point in connexion with them here. For field purposes it suffices to separate these rocks into a (1) lower series consisting of calcareous shales, and containing a fauna proper to pelitic rocks of this age. (2) An upper, mainly calcareous series, with the fauna such as might be expected to occur in the clearer waters where limestone was in process of formation. Any local change from argillaceous to calcareous is, as might be expected, accompanied by a corresponding change in the fossils. The lower series of shales graduates upward into the calcareous series. The limestone of Keisley belongs, I believe, to a higher part of this calcareous series than has been left by pre-Silurian denudation elsewhere in the area under notice. It is faulted in all round.

Below the Upper Shale-and-limestone series, which represents the Coniston Limestone Series of the areas to the west, there rises a thick mass of rhyolitic tuffs, which form the Pikes of Dufton, Knock, the north end of Rake Brow, Melmerby, and several other smaller eminences in the district. They are quite conformable to the overlying shales. Their base is not clearly seen anywhere here; but quite enough of them is exposed to show that they are not less than 1100 feet in thickness. This, there is reason to believe, is not far from their full vertical extent. Except that these rocks are (as I believe) of pyroclastic origin everywhere in this area, they very closely resemble the rhyolitic series that underlies the Coniston Limestone west of Shap, and there cannot be much doubt about their actual contemporaneity.

With the general distribution of these in the Cross Fell area we are not at present concerned. But their presence in the neighbourhood of Roman Fell has been misinterpreted. Considering the complicated nature of the geology there, this can hardly be wondered at. The facts as they appear to me are of the following kind:—Between the village of Helton and the flanks of Roman Fell, Coniston Shales of the ordinary type are seen at many places from Helton Beck southward. They are cut off on the south-west by the Outer Pennine Fault, which brings the Bunter (or St. Bees) Sandstones and Shales directly against them. The Coniston Shales dip towards the north-west at rather high angles. So that as their outcrops are traced towards the south-east, their base is reached about five hundred yards to the south-east of Helton Beck. Then rises from beneath them here, as elsewhere in this part of England, a mass of rhyolitic tuffs of exactly the same nature as those of Dufton Pike, Knock Pike, etc. These form the small hill known as the Seat. The Outer Pennine Fault runs close alongside this hill, and cuts off these tuffs on the south-west, bringing the St. Bees Sandstones into direct contact with them for a distance of several hundred yards, as may be seen in the course of Helton Sike.

On the eastern side of the Seat ranges one of the Middle Pennine Faults, which here brings up against the rhyolite tuffs a narrow strip of the alternations of submarine tuffs and argillites, which represent the seaward equivalents of the Borradale Series, and which I have named the Milburn Rocks. These in turn are cut off by another fault ranging nearer to Roman Fell. The effect of this fault is to let in a strip of volcanic rocks of yet a different type. It is these with which we are specially concerned at present. Under the name of the Roman Fell Volcanic Series, specimens collected and fully labelled by myself were for several years from 1876 onward on exhibition in the Rock Collection at the Museum of Practical Geology. I have reason to know that Mr. Marr has long been acquainted with the specimens in question; though I understand from him that he has not actually seen them *in situ*.

On the ground, these Helton Moor Volcanic Rocks may be readily found by any one used to field geology, if he will cross the Moor from the Smelt Mill at Helton along a direct line connecting that building with a point a little to the north of the summit of Roman Fell. Both points can easily be kept in view. He will cross (1) the Bunter Sandstones and Shales; (2) the Outer Pennine Fault, which runs north-westerly along the upper side of Helton Sike; (3) the Coniston Shales, seen in several places on the Moor; (4) the Rhyolite tuffs (Dufton Pike beds) of the Seat; (5) a narrow strip of the Milburn Rocks faulted in by the Middle Pennine Fault; (6) the Helton Moor Volcanic Series, and also an interesting dyke of microgranite, containing large rhombs of muscovite, like the Dufton "Granite." These are best exposed along the 1250 feet contour. When this is reached, the observer will see the rocks best by following the same elevation southward. Their outcrop extends over about seven hundred yards. These volcanic rocks will be seen to have a fairly-steady, and high, northerly dip, so that lower beds rise to the surface as the rocks are traced southwards. They consist of alternations of ashy mudstones, ashy grits, tuffs, and a few beds of lava, which occur chiefly at the north end of the exposure, and are, apparently, of an andesitic type. One or two beds of lava are markedly porphyritic, and recall the beds of Rake Brow, Melmerby (whose volcanic origin was demonstrated by the Survey in 1876).

As the beds are followed towards the south, their base is reached, and the volcanic rocks are seen to graduate downward into a group of very calcareous and partly ashy-looking shales. I have published references to this important piece of evidence on many previous occasions, and have, in addition, had the pleasure of conducting many fellow geologists over the rocks in question during the last fifteen or more years.

We are indebted to Messrs Marr and Nicholson for very valuable lists of fossils from these beds. On account of the occurrence in them of *Trematis corona*, the authors just named have called these beds the Corona Beds. The name seems to me to be not altogether a good one, and for the following reasons:—*Trematis corona* occurs in the Coniston Shales in several localities. Below these shales come the rhyolite tuffs, which are hardly less than 1100 feet in thickness. Immediately beneath them the exact sequence is not known; but I do not think that any great thickness of rock (if any at all) is missing. Then follows the series of volcanic rocks of Helton Moor, just referred to, which are certainly not less than 1000 feet in thickness. (I more than suspect that these Helton Moor volcanic rocks are the equivalents in time of those I named the Rake Brow Series, from the place of that name east of Melmerby. Certainly some beds very much like the Helton Moor beds occur at the base of the series at Rake Brow; just as rhyolitic tuffs like those of Knock come on above them.) Below the Helton Moor volcanic rocks is the Lower *Trematis corona* bed, that is to say, the fossiliferous shales mentioned above.

I think if Mr. Marr had acted upon the friendly hint I gave him in a letter some time back, he would have found that there are two *Corona* beds here, and that these are separated by a considerable thickness of other rocks, as Professor Lapworth informs me is the case in the Girvan area. Certainly the two *Corona* beds do not come together, as Mr. Marr's sections indicate.

As for the relation of these Helton Moor beds to the interesting set of strata discovered by Messrs. Marr and Nicholson at Drygill, I fail to see any reason why they may not be contemporaneous. It is now several years since I expressed the opinion that the higher Ordovicians of Cumberland were transgressive across successively lower beds of the same system as they trend towards the north; and illustrated that view by a diagram (Proc. Geol. Assoc. vol. ix. No. 7, fig. 1). This diagram was intended to express what I believed to be the facts in not only the Lake District, but also in the Cross Fell area.

It may be convenient to give here a general summary of the succession of these older rocks as developed in the area at the foot of the Cross Fell Escarpment:—

	Approximate thickness in feet.
Silurian Rocks.	
Unconformity.	
Coniston Limestone Series	+ 900
Dufton and Yarlside Rhyolitic rocks	+1100
Strata missing, probably not of great thickness.	
Helton Moor (? and Rake Brow) Volcanic Series	+1000
Helton Moor Shales...	+ 500
Break of unknown extent, probably coinciding with an unconformity, which increases in extent going northwards.	
Milburn Rocks... .. .. not less than	6500
Skiddaw Slates, of great thickness ... ... not less than	8000

The Craven Area.—I shall not attempt, on the present occasion, to deal with the many difficult problems suggested by the Bala rocks of this area. All the older Palæozoic rocks of Craven were mapped in great detail by Prof. Hughes, and were described by him, many years ago, and both Mr. Marr and I owe much of our knowledge of them to his earlier work. I may, however, state that they seem to me to be much more complex, and also very much thicker, than has generally been supposed. It is a long way from Roman Fell to Wharfe: otherwise I should be disposed to think that the beds in Craven that Mr. Marr has taken to be on the horizon of the Coniston Limestone are much lower down in the series, and that the true Coniston Limestone (here much thicker than in the typical area) was locally denuded (together with a great thickness of some rocks older in the series) before the Silurians were laid down; so that it is only left here and there. I had the advantage of going over all the details of that part of Prof. Hughes' work under his own guidance, and with the additional advantage of the long experience of Mr. Aveline. This was between 1874 and 1876. Later still, my colleague, Mr. Gunn, carefully checked all our previous work, under the superintendence of Mr. Howell, the Director for Great Britain. I think I may now venture to state on behalf of all my colleagues concerned, that not one of us is at all disposed to entertain for a moment the idea that the Bala rocks of Craven are separated from the Ingleton Green Slate Series by a fault, as Mr. Marr has shown in his section. On the contrary, the Bala calcareous-and-ashy series appears to us graduate downward by interbedding into the great series of barren reywackes and argillites, which we call the Ingleton Green Slate eries; so that the upper and the lower sections are almost separable.

Like Mr. Marr, we were all of us at first very much struck by e remarkable difference in lithological character between these edimentary rocks of Ingleton and the tuffs and lavas of the Lake istrict. Mr. Aveline, whose authority in such matters no geologist ill question, repeatedly expressed the opinion, as far back as 1874, at he could see no difference between this Ingleton Green Slate eries and the *Longmyndians*. Nor can I. Nor is there any differnce between them and the rocks of the Scottish Central Highlands, xcept that the latter rocks have undergone plutonic metamorphism, hich the Craven rocks have not. But then, on the other hand, one reat series of greywackes is very much like another, and much of e Coniston Grit, as Mr. Marr knows better than most men, is ardly distinguishable in lithological character from much of the ngleton rocks.

I see no difficulty in regarding the Ingleton rocks as old sediments ke the coarser part of the Milburn Rocks, into which marine urrents have swept the detritus from the contemporaneous denudaon of the maritime volcanoes to the north.

In conclusion there is one point that Mr. Marr has not dwelt upon t as great length as his knowledge of the subject would have arranted. It is this:—the most widely-spread types of Ordovician ocks in the north-west of England must not be looked for in the ake District proper, but in the areas where deeper-water conditions btained outside of it. The persistent types are to be found, not in id-Cumberland, but in Craven, and within the Cross Fell Inlier.

III—On the British Earthquakes of 1891.

By Charles Davison, M.A.;
Mathematical Master at King Edward's High School, Birmingham.

COMPARED with that of the year before, the British seismic record for 1891 is somewhat meagre. It includes a slight rthquake felt in North Cornwall on March 26, several at Inverarry, Ardochy, and Loch-hourn Head in Inverness-shire; and one her, believed to be that of an earthquake, at Bournemouth on ctober 25. The remarkable series of earthquakes felt between ovember 15 and December 14, 1890, in the district round Inverness ems to have ended at the latter date; for Mr. J. Birnie, a very reful observer residing at Balnafettack, informs me that he has lt none during the past year; and his evidence is especially luable, since the epicentra of nearly all the shocks must have en close to that village.

N. Cornwall Earthquake: March 26, 1891.

Time of occurrence, about 11 h. 30 m.; Intensity, IV.; Epicentrum, t. *50° 40′ N.; long. 4° 36¾′* W., *i.e.* 4 miles N. 35° E. of Camelford.

Disturbed Area.—I have received seventeen accounts of this earthquake from sixteen different places. On the accompanying map these places are represented by small discs; a cross drawn through the discs indicating that the usual earthquake-sound was also heard. At one place (Otterham), so far as I know, the sound only was noticed. At three other places near the boundary of the disturbed area, the shock does not seem to have been felt, though special inquiries were made by residents in them. These places are Egloskerry, St. Kew and Trewen; and they are represented on the map by small circles. At Laneast, Port Gavern, St. Breward, St. Gennys and St. Tudy, I have been informed that the shock was not felt, but I am not certain that this was the experience of more than one person at each of these places.

The boundary of the disturbed area, as drawn upon the map, corresponds to an isoseismal line of intensity somewhat less than IV. according to the Rossi-Forel scale. The area inclosed by it is 17 miles long, 13 miles broad, and contains about 170 square miles. Its centre is 4 miles N. 35° E. of Camelford; and this point probably coincides very nearly with the position of the epicentrum. The longer axis of the disturbed area is directed approximately north and south. About one-third of the boundary-line, it will be noticed, lies outside, the land; and its exact course in this part must of course be somewhat uncertain. The observations from Tintagel and Boscastle show, however, that its position cannot differ very greatly from that assigned to it on the map.

Nature of the Shock.—The following accounts give the most detailed information I have received:

Bolverton.—Two distinct shocks felt, separated by an interval of two or three seconds.

Boscastle.—(1) Two shocks, the first rather more intense than the second which followed after a lapse of perhaps ten seconds, a decided tremulous motion being felt both during and after the two shocks. (2) Two shocks, the second shorter and fainter than the first, and felt a second or two after it.

Jacobstow.—Two shocks, the interval between them two or three seconds.

Michaelstow.—Two shocks felt, the first very slightly, the second very decidedly, and almost instantaneously after the first.

New Mill, Poundstock.—Two shocks, a slight tremulous motion being felt before and after both of them, the first shock more intense than the second.

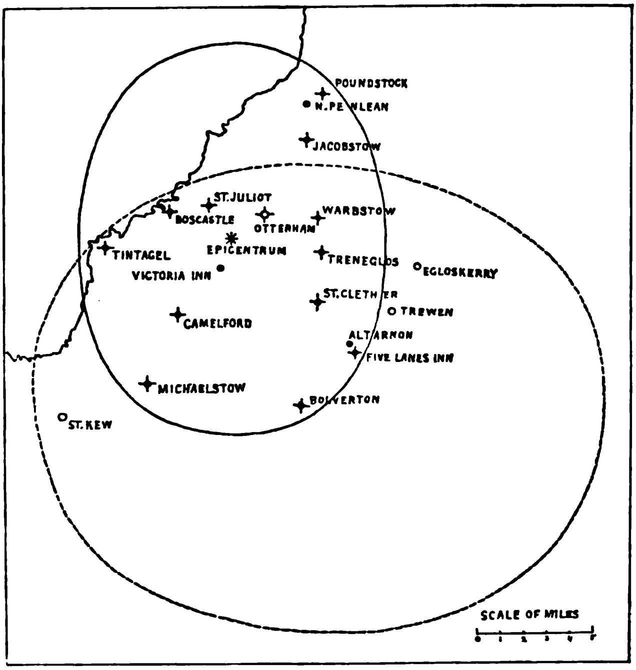
St. Clether.—Two shocks, consisting of a trembling like that caused by a sudden violent rush of wind against the house; each shock lasted about ten seconds, they were approximately equal in intensity, and were separated by an interval of a few seconds.

St. Juliot.—Two shocks, consisting of rapid and continuous vibrations, slightly increasing in intensity about the middle. The first and strongest shock lasted for eight or nine seconds, the second for five seconds, the interval between them being three seconds.

Tintagel.—Two shocks felt.

Treneglos.—Two shocks felt, separated by an interval of about fifteen seconds, no vertical motion perceptible.

Intensity.—The intensity of the shock was at IV. at the following places: Altarnon, Boscastle, Camelford, Poundstock, St. Clether, St. Juliot, Tintagel, Treneglos, Victoria Inn (near Davidstow) and Warbstow; and less than IV. at Bolverton, Five Lanes Inn (near Altarnon) and Michaelstow.



Sound-phenomena.—With three exceptions (Altarnon, N. Penlean, and Victoria Inn) earthquake-sounds are recorded at all the places of observation, and the omission at these places is probably accidental. The sounds were heard at all the places which determine the boundary of the disturbed area. They were also, I am informed, heard two miles to the east of Bolverton, so that it is possible that the sound-area may have slightly overlapped the disturbed area towards the south-east. Otherwise the two areas seem to have coincided approximately.

The sound is said to have preceded the shock at Michaelstow, to have accompanied it at Bolverton, Boscastle, Camelford, Jacobstow, St. Clether, St. Juliot and Treneglos, and to have preceded, accompanied and followed it at Poundstock.

At Boscastle, Dr. Wade informs me that the sound resembled that of a ponderous waggon going over a vacuum. It was heard while the shocks lasted and during the whole of the interval of about ten seconds between them; the intensity being nearly uniform throughout, but greatest when the vibrations were felt, and slightly less during the interval between them. Another observer at the same place compares the sound to that made by an unusually heavy waggon going over a bridge, but it was not heard by him during the whole of the interval between the shocks. "There was silence," he remarks, "for a second or two between the rumbles; the latter went off as the sound of a heavy ground sea after breaking on the shore; it was shorter and fainter than the first." At every other place the sound ceased for a greater or less time between the shocks. At Michaelstow a loud rumbling sound, resembling the passing of a very heavy vehicle over a hard road, preceded each shock, growing rapidly in volume and dying quickly away. At St. Juliot, again, the sound accompanied each shock, varying only slightly in intensity, but greatest at the moments when the vibrations were felt.

Origin of the Shocks.—The first point to be determined is the origin of the double shock, and of this three explanations may be given. (1) The seismic focus may have consisted of two detached portions, or have contained two regions of maximum initial intensity; (2) there may have been a repetition of the originating impulse at one and the same spot; or (3) a repetition of the originating impulse at another and different spot; the focus, or line, joining the foci, being in any case directed north and south.

If the first explanation were the correct one, the interval between the two shocks would have been greatest in the continuation of the line joining the foci, *i.e.* in the north and south parts of the disturbed area, and least in the east and west parts. Without placing too great a reliance on the estimates of this interval given above, it is clear that they offer little support to this theory. At Michaelstow, indeed, the second shock was said to follow "almost instantaneously" after the first, but the interval was yet long enough to allow the rumbling sound to cease and to be heard again before the second shock; and Michaelstow is not far from the southern boundary of the disturbed area. The second explanation is also out of the question, on account of the different relative intensity of the shocks at different places.

There remains the third theory, and the evidence, such as it is, seems clearly in its favour. At all parts of the disturbed area there would be a perceptible interval between the shocks, provided the interval between the initial impulses was not equal to the time required for the earth-wave from a further and earlier focus to overtake that from a nearer and later one. The distance between the foci will, however, account to some extent for the variations in the estimates of the interval between the shocks.

More important evidence is furnished by the different relative intensity of the two shocks at different places. We have seen that the first shock was the stronger at Boscastle, Poundstock, and St. Juliot, all lying to the north of the epicentrum; the second decidedly the stronger at Michaelstow, near the southern end of the disturbed area; while at St. Clether, which is near the eastern boundary, the intensities of the two shocks were approximately equal.

I conclude, then, the shocks were really distinct, the focus of the second being to the south of that of the first; and it is obvious that, if this were the case, the interval between the two shocks should have been least at the southern end of the disturbed area, an inference which agrees with the estimate already quoted of the apparently short interval at Michaelstow.

The position indicated on the map as that of the epicentrum probably corresponds closely with the superficial position of the centre of intensity of the whole seismic focus. The distance between the two foci may have been as much as two or three miles, but Dr. Wade's interesting observation at Boscastle of the sound being heard during the whole interval between the shocks seems to show that the foci were not completely isolated. If the shocks were due to fault-slipping,[1] we may infer, from the form of the disturbed area and from the facts summarised in the preceding paragraphs, that the direction of the fault must be north and south. Boscastle, again, is the only known place where the sound was heard continuously between the two shocks, and, as mentioned above, the sound-area may have overlapped the disturbed area along its south-east margin. These facts seem to indicate, but not with certainty, (1) that Boscastle must be near the spot where the normal to the seismic focus meets the surface of the earth, and (2) that the upper margin of the focus from which the sound-vibrations proceeded lay to the east or south-east of the epicentrum; *i.e.* that the fault must hade to the westward. Lastly, if this conclusion be correct, the line in which the fault intersects the surface must pass to the east of the epicentrum, and at a distance from it probably not much greater than one or two miles.[2]

Summing up on the supposition that the earthquake was fault-formed: the first shock was probably caused by a slip within a small area about a mile north of the point marked as the epicentrum; but the slip continued southward for about two miles, though so slight in extent that only earthquake-sounds were produced, an interval of perhaps five or more seconds being necessary for the slipping over this distance to take place; at the southern end the slip being again great enough within a small area to produce a shock of approximately the same intensity as the first.

It is interesting to notice the relation between this earthquake and that felt in East Cornwall on October 7, 1889. The boundary of the disturbed area of the latter is indicated on the map by a dotted line. Its epicentrum lay about 2¾ miles S.W. of Altarnon, and the longer axis of the disturbed area ran east and west, *i.e.* parallel to the direction of folding in the district. The earthquake of 1889 was therefore a *longitudinal* earthquake, and that of 1891 a *transverse* earthquake.

---

[1] There is no fault marked in the Survey Map of the district with which the earthquake can be connected.

[2] The fact that no shock was noticed at Otterham is in favour of the position above assigned to the fault; for, if the earthquake were due to fault-slipping, the earth-waves in the rock-masses on either side of the fault would start in opposite phases of vibration and might possibly interfere to a very great extent along the line of fault. (See a paper "On the Existence of Undisturbed Spots in Earthquake-shaken Areas," GEOL. MAG. Dec. III. Vol. III. 1886, p. 157).

Authorities.—The published accounts of this earthquake are very scanty, and for all that is of value in the preceding description I am indebted to the kindness of the following ladies and gentlemen who courteously replied to my inquiries either addressed to them or printed in two or three of the local newspapers: Bolverton, Rev. S. G. Gregory; Boscastle, Dr. A. Wade and Mr. J. Brown; Camelford, Mr. E. Rogers; Egloskerry, Rev. W. S. Sloane-Evans; Five Lanes Inn, Mr. A. Chapman; Jacobstow, Rev. F. T. Batchelor; Michaelstow, Rev. W. H. Gillett; Otterham, Rev. E. H. Archer-Shepherd; Poundstock, Mr. J. D. Graf; St. Clether, Rev. F. Partridge; St. Juliot, Mr. W. H. Sanders; St. Kew, Mr. W. Hitchin; Tintagel, Miss B. F. Cooke; Treneglos, Mr. J. C. Chapman; Victoria Inn, Mrs. Greenwood; Warbstow, Mr. W. Petherick.

EARTHQUAKES IN INVERNESS-SHIRE.

For the following list of shocks I am indebted to the valuable observations of Mr. John Grant of Invergarry; Mr. Murdoch Matheson, who has removed from Feddan to Ardochy; and Mr. A. Campbell, of Loch-hourn Head. Ardochy lies on the north side of Loch Garry about a mile from its west end. At Glen Quoich and Glen Kingie, earthquake-shocks are occasionally felt, though none has been observed at either place during the past year by Mr. D. Grant and Mr. A. G. Foster, both of whom are doing useful work in recording the occurrence of earthquakes felt by them. It is worthy of notice that all the six places here mentioned lie close to a line joining Invergarry and Lochhourn Head. Every one of the seventeen or eighteen shocks mentioned below was felt by more than one observer.

Feb. 24.	22h. 55m., Invergarry, resembling the sound of a carriage.
„	23h. 20m., Loch-hourn Head, a rumbling noise with a slight movement, lasting fully ten seconds. This shock may be the same as the preceding, but the distance between Invergarry and Loch-hourn Head is 23 miles, and no shock is recorded about this time at either Ardochy, Glen Quoich or Glen Kingie.
Feb. 25.	1h. 15m., Invergarry, like a heavy carriage passing.
Mar. 1.	15h. 15m., Ardochy, a shock lasting eight seconds.
„	21h. 25m., Ardochy, a stronger shock than the preceding, lasting four seconds, and preceded by a rumbling noise.
Mar. 2.	22h. 15m., Invergarry, like a heavy carriage passing.
Apr. 24.	14h. 30m., Ardochy, a shock of intensity IV., followed by a noise resembling thunder.
Aug. 27.	4h. 30m. and 6h., Invergarry, like a heavy carriage passing.
Aug. 30.	16h. 15m., Invergarry, the same.
Nov. 16.	10h. 25m., 14h. 15m., and 20h. 45m., Ardochy, slight shocks without any accompanying noise.

Dec. 6. 9h. 55m., Invergarry, like a heavy carriage passing.

Dec. 26. 1h. 20m., Loch-hourn Head, a very slight noise and trembling of the floor on which the observer was standing.

Dec. 28. 20h. 20m. and 21h. 24m., Invergarry, like a heavy carriage passing.

Dec. 30. 9h. 45m., Invergarry, like a heavy train crossing a bridge.

DOUBTFUL EARTHQUAKE.

The following shock is entered under this heading, having been noticed by only one observer; but, judging from the careful description, I believe there can be little doubt as to its seismic nature.

October 25, 1891, *about* 16*h.*, *Bournemouth.*—A notice of this shock by Mr. Henry Cecil appeared in *Nature* (vol. 44, p. 614), and this, together with a more detailed description which Mr. Cecil kindly sent me, is the source of the following account. A dull thud was heard, as of a heavy fall underground, and instantly afterwards (all but simultaneously with it) a single momentary shock without any preceding or following tremor. The observer's eyes were directed at the time on a plant resting on the table beside him, and, when the shock occurred, the long, pendant, lightly-poised leaves of the plant were violently agitated, waving up and down through a large arc for several seconds. The movement of the ground must have been vertical, and Mr. Cecil remarks that his impression was that it was first upward and then downward. It being Sunday afternoon, almost all traffic was suspended, but, shortly after the shock, a heavy carriage passed along the adjoining road without producing any perceptible movement in the plant. Mr. Cecil informs me that he has felt several slight shocks at Bournemouth, and he believes that in the present case the sound and shock were of seismic origin.

IV.—WAS THE BOULDER-CLAY FORMED BENEATH THE ICE?

By G. W. BULMAN, M.A., B.Sc.;
Corbridge-on-Tyne.

GEOLOGICAL opinion is still divided on the subject of the formation of the Boulder-clay. By some it is held to be the sole work of the ice, and accumulated beneath it; by others it is looked upon as a marine deposit, though deriving its materials from the grinding action of the ice-sheet or glacier. Some geologists, again, hold that the "Till"—as distinct from the Boulder-clay—was formed beneath the ice, but that the latter is a marine deposit laid down in glacial seas.

Neither the first nor the third of these views can as yet be said to have received the stamp of geological certainty, for it has not been conclusively shown that any such deposit is being formed beneath the ice at the present day; nor can it be inferred from what we know of the properties of ice in the form of glacier or ice-sheet that such a deposit *ought* to be the result of its action.

Thus no deposit analogous to Boulder-clay is found in Switzerland where the ice has retreated within recent times. With regard to this point Prof. Bonney writes as follows:

"The Glaciers of the Swiss and Savoy Alps have been retreating for several years, hence, if anything like ground moraine existed, this would be a very favourable time for observing it. In no case have I been able to find signs of any deposit resembling Till or Boulder-clay; the detrital matter which is scattered, generally sparsely, over the slope left bare by the retreating glacier has fallen from its surface, like ordinary terminal moraine. Further, by availing myself of crevasses, etc., I have made my way occasionally for some little distance beneath the ice. Nothing has been seen but bare rock, with now and then a film of mud or a passing stone. In short, the result of an experience of some years has convinced me, that if anything like the Till or Ground Moraine of recent glacialists exists in the Alps, it is a very local and exceptional phenomenon."[1]

And so we find a tendency among those who believe the Boulder-clay was accumulated beneath the ice, to push back the question of its origin from the comparatively known regions of Alpine glaciers to the unknown sub-glacial area of Central Greenland.

Thus Sir A. Geikie refers to what *must* be taking place beneath a vast continental ice-sheet:

(1) "In such comparatively small and narrow ice-sheets as the present glaciers of Switzerland, the rock bottom on which the ice moves is usually, as far as can be examined, swept clean by the trickle or rush of water over it from the melting ice. But when the ice does not flow in a mere big drain (which after all, the largest Alpine valley really is), but overspreads a wide area of uneven ground, there cannot fail to be a great accumulation of rubbish here and there underneath it. The sheet of ice that once filled the broad central plain of Switzerland between the Alps and the Jura certainly pushed a vast deal of mud, sand, and stones over the floor of the valley. The material is known to Swiss geologists as the *Moraine profonde* or Grundmorane (=Boulder-clay, Till, or bottom-moraine)" (Text-Book of Geology, p. 411).

(2) "We know as yet very little regarding its (the Grundmorane) formation in Greenland. Most of our knowledge regarding it is derived from a study of the Till or Boulder-clay in more southern latitudes, which is believed to represent the bottom moraine of an ancient ice-sheet (*ibid.* p. 417).

The weakness of the argument is further illustrated by the following passage from the Physical Geology of Prof. Green, in which I have italicised certain parts:

"We have already seen that under such a sheet [continental ice-sheet] there is *probably* formed an accumulation of clay and stones known as Moraine profonde or Grund-moräne, and Till resembles exactly what we *picture* to ourselves that this deposit *must* be like. There would be weight enough to give rise to the intense toughness and the close and irregular packing of the stones, and the scratching and polishing would be produced as the mass was moved hither and thither by the flow of the ice. . . . . .

---

[1] Geol. Mag. Vol. XIII. p. 197.

Though the existence of the Moraine profonde is *to a certain extent hypothetical*, the *probability* that such an accumulation is formed beneath large ice-sheets is so great, and its character, *if it exists, must be so exactly* that of Till, that nearly all geologists are now agreed to look upon the latter as having been formed by the grinding and wearing away by an ice-sheet of the ground on which it rested" (p. 264).

But as far as evidence from Greenland is available it throws as little light on the origin of Boulder-clay as the Swiss valleys. Thus Nordenskiöld describes an area lately left by the ice as containing no moraines, and in his description makes no mention of Boulder-clay: "We passed, in fact, over ground that had but lately been abandoned by the inland ice. . . . . Everywhere occur rounded, but seldom scratched, hills of gneiss with erratic blocks in the most unstable positions of equilibrium, separated by valleys with small mountain-lakes and scratched rock surfaces. On the other hand, no real moraines were discoverable. These, indeed, seem to be commonly absent in Scandinavia; and are, generally speaking, more characteristic of small glaciers than of real Inland Ice" (Arctic Voyages, Macmillan, 1879, pp. 169, 170).

And further, in describing the clay-beds of Greenland, Nordenskiöld speaks of them as formed *outside* the ice-sheet:

"The material of the clay-beds has evidently been deposited by the glacier rivers whose muddy water everywhere burst out from under the inland ice, but in general the deposits are sea formations, *i.e.* they have been deposited under the level of the sea" (Geol. Mag. Vol. IX. p. 410).

And no deposit resembling Boulder-clay is described by him as occurring on that strip of Western Greenland not covered by the ice-sheet at present.

Similar remarks may be made with regard to those areas in America where a retreat of the ice permits an examination of the ground recently occupied by it. In the American Journal of Science, March, 1892, for example, is an interesting description of Mount St. Elias and its Glaciers. Where the ice has retreated glaciated surfaces are seen, but *no Boulder-clay.* Spread out, however, over the whole area between the ice and the sea is a mass of stony moranic matter. *Streams from the glaciers carry the finely-ground rock matter into the sea.*

The probability or otherwise of the Boulder-clay having been formed *beneath* the ice may be further considered in the light of what we know of the physics of glacier action. To meet the requirements of the geologist, the ice, in the form of glacier or ice-sheet, must accomplish—and apparently *does* accomplish—a variety of seemingly incompatible actions. It must clear the ground of superficial accumulations and grind and polish the rock below, while at the same time it must glide over loose deposits of clay and stones without disturbing them; it must round and polish certain stones while carrying others for long distances without taking off their sharp edges; it must hold firmly embedded in its lower surface stones with which to striate and groove the rocks below, while at the same time it leaves a large number behind to form the moraine profonde.

And when we turn to the glaciers themselves we see them accomplishing a series of actions as apparently incompatible. For while the ice *flows* along its bed more or less like a river, it yet polishes and striates the rocks below, apparently by holding stones firmly grasped in its lower part; and while grinding down the rocks over which it passes to the finest powder, it has yet been observed to rise gently over loose deposits of clay and stones without disturbing them; at times it allows stones to sink into it, so that its surface moraines disappear, while at other times it works up the stones from below to the surface, and they appear again.

While the anomalies of Glacial action are so great it would be rash to assert that Boulder-clay cannot be formed beneath the ice, but the great fact of constantly running sub-glacial streams renders it improbable. These streams laden with fine rock-flour issue from the termination of glacier and ice-sheet summer and winter. How far such streams ascend the glacial valleys it is difficult to say. *Probably* they extend at least as far as the point where the névé gives place to the ice-river. Such a conclusion, at least, seems to follow from certain considerations as to the probable temperature beneath a considerable sheet of ice or snow.

Ice and snow are bad conductors of heat, and hence the lower surface of a thick ice-sheet will tend to take the temperature due to the surface of the earth—say, about 50° F. The pressure, moreover, of the superincumbent ice will tend to liquify the lower portion. Such streams running beneath the entire extent of the glacier proper would readily account for the number of rounded stones found in the Boulder-clay, as well as for intercalations of sand and gravel; but do not permit the supposition of a sufficient quantity of rock-flour being left behind to form more than such fragmentary fringes and patches as a river leaves along its course. The *greater part* of this finely ground rock matter will be carried *beyond* the limit of the ice, and if the glacial streams spread out over level plains deposits of clay of considerable extent *might* be formed on land. Most of this sediment, however, will be laid down in water. If we study the distribution of glacial mud in Switzerland at the present day we find it is mostly laid down in lakes. Many of its glacial mud-laden streams fall into lakes from which they emerge clear and pure, having deposited their sediment therein. Thus the Rhine flows into Lake Constance and the Unter Sea, the Rhone into the Lake of Geneva, the Aar into the Lakes of Brienz and of Thun, the Ticino into Lake Maggiore, the Reuss into the Lake of Lucerne.

This fine sediment would provide the clay, and if *boulders* could at times be carried in, the conditions for the formation of boulder-clay would be present in these Swiss lakes to-day. And, whatever may be the case now, when the ice extended further and reached the lakes, small bergs would be frequently detached, and melting, allow their burden of stones to sink to the bottom of the lake amid the clay there accumulating.

Prof. Nordenskiöld, again, has described how a similar deposit is being formed in Greenland at the present day.

"At the foot of the glacier," he writes, "we often find, as in fig. 2, ponds or lakes in which is deposited a fresh-water glacial-clay, containing angular blocks of stone, scattered around by small icebergs" (Arctic Voyages, pp. 170, 171, Macmillan, 1879).

But it is when we turn to the sea that we find the most promising method of accounting for the origin of Boulder-clay in general. For it seems obvious that deposits analogous to Boulder-clay must be accumulating on a large scale in the seas off the coasts of Greenland and other arctic lands. Sub-glacial rivers, laden with the finer products of glaciation, are discharging themselves into the sea throughout the year. Icebergs, also, are constantly being formed and floated away with their loads of debris. Part of this debris no doubt will be deposited only when the bergs melt in more southern latitudes; but a part will also be laid down near the coast and among the finer sediment by the overturning of the bergs, which not unfrequently happens. And it is, perhaps, worthy of note that large quantities of glaciated stones may be carried by such bergs and deposited amid accumulations of clay taking place in latitudes far south of the limits of glaciation. A clay full of glaciated stones may thus *not necessarily* imply the glaciation of the latitude where it occurs.

The opinion that the Boulder-clay was thus formed in the sea has been expressed by eminent geologists. Thus Sir J. W. Dawson in his "Handbook of Geology for Canadian Students," expresses his opinion thus:

(1) "Under these circumstances moraines were formed on the land, and sheets of stony clay with boulders in the sea, forming what has been termed the Boulder-clay or "Till" (p. 114).

(2) "That this Boulder-clay is a sub-marine and not a sub-aerial deposit, seems to be rendered probable by the circumstance, that many of the boulders of the native sandstone are so soft that they crumble immediately when exposed to the weather and frost" (p. 154).

And Prof. Boyd-Dawkins writes: "The hypothesis . . . . . that the Boulder-clays have been formed on land is open to the objection that no similar clays have been proved to have been so formed, either in the Arctic regions, where the ice-sheet has retreated, or in the districts forsaken by the glaciers in the Alps or Pyrenees, or in any other mountain-chain. Similar deposits, however, have been met with in Davis Strait and in the North Atlantic, which have been formed by melting icebergs; and we may therefore conclude that the Boulder-clays have had a like origin" ("Early Man in Britain," pp. 116, 117).

The chief difficulty in the way of this marine origin of the Boulder-clay is perhaps the absence of lamination, so characteristic of deposits in water. But a consideration of the facts of the case suggests a possible explanation. The two general causes of original lamination —indeed I am not acquainted with any other—are the intermittent supply of sediment, and the presence of flat plates of mica. Both of these are probably absent in the case of the deposit in question. The ice provides a *continuous* supply of rock flour, and rivers laden with it flow from the glacier and ice-sheet all the year through; and it permits the existence of no large flat plates of mica.

The general conclusion, then, to be derived from a study of glacial action seems to be that while the greater part of the rock-flour which goes to form the clay is carried beyond the limits of the ice and laid down in lakes, the sea, or on land, fringes and patches of the same may be left behind in the valleys occupied by the glacier or ice-sheet.

V.—Glacial Geology: Old and New.

By T. Mellard Reade, C.E., F.G.S., F.R.I.B.A.

Historical and Personal.

OVER twenty years ago I commenced the study of the glacial deposits of the neighbourhood of Liverpool, and as the observations grew they came to embrace a considerable share of the drainage-basin of the Irish Sea.

I have personally inspected and kept full records of all of the important artificial excavations likely to throw light upon the subject, in addition to examining and making sections of the natural exposures of glacial drift which abound on the north-west coast of England, the coast of Wales, and in the river valleys draining into the Irish Sea, and to a lesser extent the drift on the east-coast of Ireland and the south of Scotland. These observations, together with others in districts outside the special area of my work, have been communicated to various Societies and Magazines.[1]

This being my record, and glacial geology having during my time gone through several phases, it may perhaps interest some of the readers of the Geological Magazine if I give a *resumé* of the views I have been gradually led to adopt.

---

[1] Proc. of Liverpool Geol. Soc. 1872–73, pp. 31, 32, pp. 42–65; 1873-74, pp. 50–72. Q.J.G.S. vol. xxx. p. 27–41, 1874. Proc. of Liverpool Geol. Soc. vol. iii. pt. 1, pp. 19–27, 1875. Geol. Mag. Dec. II. Vol. III. p. 480, 1876. Proc. of Liverpool Geol. Soc. vol. iii. pt. 3, pp. 241–43, 1877. Geol. Mag. Dec. II. Vol. IV. pp. 38, 39, 1877. Q J.G.S. vol. xxxiv. pp. 808–810, 1878; vol. xxv. pp. 679-681, 1879. Proc. of Liverpool Geol. Soc. vol. iv. pt. 1, pp. 64–89, 1879; vol. iv. pt. 2, pp. 139-153, 1880; vol. iv. pt. 3, pp. 216–233, 1881. Q J.G.S. vol. xxxviii. pp. 222–238, 1882. Trans. Geol. Soc. Glasgow, vol. vi. pt. 2, pp. 264–276, 1882. Proc. of Liverpool Geol. Soc. vol. iv. pt. 5, pp. 364–380, 1883. Q.J.G.S. vol. xxxix. pp. 83–132, 1883. Trans. of Liverpool Geol. Asso. vol. iii. pp. 93–101, 1883. Q.J.G.S. vol. xl. pp. 267–269; vol. xl. pp. 270–272, 1884. Proc. of Liverpool Geol. Soc. vol. v. pt. 1, pp. 74–83, 1885. Q.J.G.S. vol. xli. pp. 102–107; vol. xli. pp. 454–456, 1885. Proc. of Liverpool Geol. Soc. vol. v. pt. 4, pp. 377–379, 1888. Nature, vol. xl. p. 246, 1889. Proc. Liverpool Geol. Soc. vol. vi. pt. 2, p. 188, 1890; vol. vi. pt. 3, pp. 316–321, and pp. 333–4, 1891. Geol. Mag. Vol. VIII. Dec. III. p. 291, 1891. Proc. Geol. Soc. 1892.

On commencing the inquiry I had no idea whither my observaons would lead me, and had no prepossessions. I quickly found, owever, that I came into collision with one of the prevailing views —I had almost said dogmas—of the day.

The drift of the north-west of England had been arranged in tripartite series consisting of, in ascending order, Lower Boulder lay, Middle or Interglacial Sands and Gravels, and Upper Boulder-ay. My observations led me to believe that there were no sufcient grounds for such a geological division, and that the whole of he drift deposits were one glacial series from top to bottom. This view is now the one generally adopted, and also as I understand y the new school of glacialists who ascribe these deposits to the loughing up of the Irish-Sea bottom by land ice. And this brings o my mind the fact that there has been a concurrent change of osition on the part of the land-ice glacialists, for the old school elieved in the occurrence of several interglacial periods and thought hey could read the record of them in the deposits.

Until lately the preponderance of opinion among geologists who have studied the subject in the field was that the glacial deposits of he north-west of England were sea-bottom *in situ* and that the high-level sands and gravels indicated a submergence of the land n glacial times to at least 1400 feet.

The late Mr. Belt struck a new note when he boldly declared his belief that the high-level drift of Moel Tryfaen, in Carnarvonshire, had been pushed up into its present position by a sheet of land-ice raversing the Irish Sea.[1] Mr. Belt was listened to by few at the ime, but in the whirligig of time he is now having ample revenge.

The late Professor Carvill Lewis, fresh from his experiences in America, revived this idea of Belt's in a modified form, and he also met with much opposition. Since his death the idea has fructified, and we now have an energetic band of geologists who are bent on nothing less than raising what was considered at first to be a "wild dea" into a geological dogma.

Whether there has been justification for this veering round of geological opinion it will be our object presently to inquire. In the meantime it is sufficient to suggest that it is not the province of geological enquiry to search out facts with the object consciously or unconsciously of running a theory, yet this is one of the many pitfalls against which geological reasoners have to be constantly on their guard.

THE GLACIAL DRIFT OF THE IRISH-SEA BASIN AND ITS SYSTEM OF DISTRIBUTION.

Low-Level Boulder-clay and Sands.

The whole of the plains of Lancashire and Cheshire are, with he exception of local patches, covered with a mantle of Boulder-clay and sands of varying thickness, from a few feet in the more exposed localities to 160 feet in the deeper river channels. Both he clay and sands generally contain remains of mollusca in a more or less fragmentary condition.

---

[1] Nature, vol. x. pp. 25, 26, 1874.

The Boulder-clay is usually of a brown colour, sometimes unctuous, and contains boulders and fragments of Northern rocks from the maximum of over 20 tons down to the finest gravel. The boulders are to the extent of fully 50 per cent. either planed or striated or both, and sometimes on several faces. They are often considerably rounded and the finer gravel to be obtained by washing the clay is extremely waterworn. The sand, if separated from its clayey matrix, is much rounded, some of the grains being extremely polished.

The proportion of sand in the clay is much greater than would at first be thought, varying from 20 to 60 per cent. There is no geological difference between the Sands and the Boulder-clays, gradations from the one to the other can be met with though often they come together in sharp juxtaposition. If we trace these drift deposits up the valleys from the sea to the source of the rivers flowing in them, we find that the nature of the matrix of the drift lying in them is largely dependent upon the nature of the rocks the rivers traverse,[1] that is to say, the sandy and gravelly drift increases when the rivers above them flow through sandstones and rocky ground as in the Dee above Chester, and the Mersey and Irwell in the neighbourhood of Manchester, while the rivers flowing over the New Red Marl have brought down an unctuous clay like that deposited by the Weaver in the Buried Valley of the Mersey at Widnes. Thus, while the contained stones have come from the northward, with the possible exception of some sandstones and gypsum of the New Red Marl, the matrix consisting of clay and sand has to the larger extent come down the river valleys.

If we extend our observations further south into Shropshire we find a still greater development of sands. The drift by the Severn at Shrewsbury is nearly all red sand, the waterwashed *débris* of the New Red rocks. The erratics are still plentifully strewed about the county, and the well-known Eskdale granite and the grey granite of the south of Scotland, together with the andesitic rocks and volcanic ashes from the English Lake district are distinguishable. It is also a fact worth noting that on the plain of New Red Marl in Cheshire the drift sands and gravels are more developed than the Boulder-clay; often they lie directly upon the marl without the intervention of any Boulder-clay. I have observed this also in Shropshire.

High-Level Sands and Gravels.

At Moel Tryfaen, Carnarvonshire; at several places in Flintshire (Moel-y-Crio among them); between Minera and Llangollen, Denbighshire; at Gloppa, near Oswestry; at the Setter's Dog, near Macclesfield, and the Three-Rock Mountain, near Dublin, sands and gravels are found varying from about 1000 to 1400 feet above the sea-level. These sands and gravels contain shells of mollusca, speaking generally, of a similar *facies* to those fragments found in the Low-level Boulder-clay and sands. More perfect specimens have been found at these high levels, especially at Gloppa, by Mr. Nicholson, F.G.S., than re generally met with in the Drift of the plains. Drift with shells is met with at various places at levels intermediate between the Low-level Boulder-clay and sands and the High-level sands and gravels. This Drift is usually laminated and current-bedded. At Moel Tryfaen, where I devoted a good deal of study to the Drift, there is a much greater preponderance of erratic stones, such as Lake District rocks and Scotch granites, flints supposed to come from Antrim, with an admixture of Carboniferous limestone which may be from Anglesey, and true Anglesey crystalline schists, than is contained in the Drift of the coastal plain which reaches from sea level up to the 400 feet contour. It is rather a remarkable fact that in this high-level Drift I found a piece of Shap Fells rock in the form of a rounded pebble identified by Mr. Alfred Harker, F.G.S., as from one of the numerous offshoots of the granite mass of Shap Fells. I mention this specially because during the whole time I have been observing I have never met with any Shap Fells granite on this side of the Pennine Chain, either in Lancashire, Cheshire, or North Wales.

---

[1] Quart. Journ. Geol. Soc. vol. xxxix. pp. 83–132.

The High-level sands and gravels of Tryfaen are overlaid on the eastern side of the excavations with a stony Till, evidently of local derivation, and containing nearly all local rocks. In one place a laminated bed of the sands inosculated with the Till, which also contained pockets of the sand. This is a very striking feature which has only been developed of late by the progress of the excavations. The stones contained in the sands and gravels are much waterworn, and there is a very much smaller proportion of them striated than what we find in the Low-level Boulder-clay. The grains of sand are also much rounded, waterworn, and polished. The Till also contains a proportion of these highly polished grains, and I found on washing some of the locally formed Till lying at a level of 800 feet above the sea, between The Rivals and Mynydd Carnguwch, that this also contained highly worn and polished quartz grains.

Drift of the Coastal Plain adjoining Tryfaen.

The Drift of the coastal plain adjoining Tryfaen is well exposed in coast sections, and consists more largely of material from the Snowdonian Range, both as regards boulders and the matrix, which is largely made up of the debris of slate rock and small slate flakes. An arched stratification is seen in some of the sections. The Till can be examined in numerous sections cut by the streams through the coastal plain, and a strict search almost everywhere yielded pebbles of Eskdale and other erratic granites, but seldom any fragments that could be described as "boulders."

Mechanical analyses of twenty samples of the Till from various localities, with one exception, yielded the rounded and polished quartz grains. In some cases I found small shell fragments, and ample evidence was accumulated that the drift of the coastal plain was an intimate mixture of the debris of the Snowdonian rocks and erratic material from the North, and in some cases from Anglesey.

Tracing the coast sections south-westwardly, they gradually put on a more distinctively marine character, until at Nevin they assume the ordinary form of stratified drift-sands with shell fragments.

Significance of the polished quartz grains.

It will be necessary to turn aside here to point out the value I attach to the discovery of the prevalence of rounded quartz sand in the Till. I have been making a very exhaustive examination of sands from various parts of the world, and I find that contrary to received ideas marine sands are, on the whole, much more rounded than river sands. Indeed, river sands are generally little rounded, and, excepting in a river like the Amazon, I can find no parallel to the rounding of the grains of sand now dredged from the Irish Sea. Blown-sand of sand-dunes is not distinguishably more worn than the sand of the shore from which it is derived. When we find these highly-polished grains mixed up with angular and little worn fragments of Snowdonian rocks forming the bulk of the Till of the coastal plain, it is evident that they are of sea origin, and serve as certainly as the fragmentary shells of Molluscs to declare this fact. I consider this an important discovery, which may, taking surrounding conditions into consideration, help to settle many disputes as to the marine or freshwater origin of certain deposits. In the present case, of course, the rounded grains can tell us no more of how they got to the high-levels than the shells of the Molluscs, but more of this presently.

Distinction between the Marine Drift of the Plains and Mountain Drift.

Where the Marine Drift of the plains approaches a mountainous district, and the base can be seen, it usually lies upon a Till made up almost wholly of local materials derived from the mountains. In some cases the Marine Drift is absent. At various points along the coast of Merionethshire, and in Mid-Wales, the local Till is prominently displayed in coast sections, but where a large estuary valley opens out on to the coast, and sections display the nature of the Drift, we find, as in the neighbourhood of Towyn, distinctly Marine Drift in some places, and a mixture of Mountain and Marine Drift in others. The stony Till clings to the mountain sides, the Marine Drift comes in more strongly as it is distant from the mountains. This is a rule to which, personally, I have seen no exceptions.

Theories of Origin.

Most of the details upon which the preceding sketch is founded, with the exception of those relating to the North and Mid-Wales coast, have been published. It is very necessary that details should be published, but the Drift is so complicated that it is very difficult, if not impossible, to describe it geologically in the sense that other formations, both older and younger, can be described. It is this that has beset the path of most glacialists, and the attempts to reduce the Drift deposits to geological order and system have been the fruitful source of many failures.

So far as the Drift in the districts described in these pages is ncerned, I long ago arrived at the opinion that no good could be t out of it—that is, no intelligible story—until we recognized it one series of glacial deposits. On this principle, with the facts lready stated before us, I propose to discuss the two opposing eories of the Glacial Drift, namely, the land-ice and the glacio-arine or submergence theory.

The Land-Ice Theory.

The present form of this theory postulates that during the period hen the Drift, as we see it now, was formed, the relative levels of he sea and land were the same as now, and that a great ice-sheet dvancing from the North over the Irish-Sea bottom ploughed out he deposits, re-arranged them, and pushing them before it, or onveying the materials frozen in the bottom of the ice, spread hem over the lowland plains, and even pushed the sands and ravels with shells up to the high levels in the instances already amed. To the obvious objection that the Drift bears indisputable igns of aqueous deposition, it is answered that the current-bedded ands and gravels are due to the washing from the melting of the ice t the termination of and underneath the Mer-de-glace.

Physical conditions involved.

Before describing what the deposits themselves have to say to his theory, let us picture to ourselves what it as a matter of physics nvolves. The gathering ground of such a glacier could at first nly be the land area which, by the terms of the postulate, was the ame as now. A glance at the Map of the British Isles is sufficient o show that the snow-field could not have been above double the rea of the sea it had to displace. The ice-front advancing over the rish Sea would have had an average length of one hundred miles. he waste by melting would have been enormous, so that an ntensity of glacial conditions far in excess of those of Greenland of he present day would have to be granted.

Probable Effect on the Sea Bottom.

If, however, for the sake of discussing the question, we grant oth the necessary conditions and their result, the ice-sheet, what ould be the probable effect on the sea bottom? Unfortunately we ave very little to guide us, for it is one of the weakest places in his theory that there are no analogous modern examples that we an appeal to. Even with those glaciers that displace the sea from n inlet like the Malaspina Glacier of Mount St. Elias in Alaska,[1] it s impossible to say what effect the glacier has had on any deposits hat may previously have occupied the bottom. We know, however, hat glaciers frequently over-ride loose deposits on land without isplacing them, while in others they erode their beds. By the erms of the postulate Pre-glacial deposits must have occupied the rish Sea before the over-riding of the ice-sheet bringing its load of northern rocks along with it. A short Iceberg period must have preceded the final development of the Ice-sheet, even on this theory. and the products of this interval might get ploughed up and mixed with the products of the Ice-sheet. But what has become of the Pre-glacial deposits? I have examined most artificial exposures in Lancashire and Cheshire calculated to throw light upon the subject, but nothing in the form of a Pre-glacial deposit have I ever seen. The Alexandra Docks at Liverpool and the Docks at Garston gave grand opportunities for inspecting the rocky floor below tide level, the Mersey Tunnel also, in a lesser degree, but everywhere the glacial deposits rest directly on the bed-rock or the debris of the bed-rock. Borings at Widnes and well and shaft sinkings at various places in the Mersey Valley, all below the level of the sea, tell the same story. So far as we know, and I have seen nothing recorded to the contrary, the glacial deposits, with local variations, are the same from the top to the bottom of the series. The "Gully Gravels" lying in depressions down to 160 feet below the sea level are glacial, as shown by the rocks from which they have been derived being the same as those in the Boulder-clay. If, as is contended, the Drift of Lancashire and Cheshire is ploughed-up Irish-Sea bottom, it is very remarkable that it possesses such homologous characteristics throughout, and that the Pre-glacial deposits have been so thoroughly mixed with the materials brought by the land-ice that there is no distinguishable difference from the top to the bottom of the series. Not only are Pre-glacial deposits not to be found *in situ*, but not a scrap or shred of anything of the sort have I ever found embedded in or associated with the Boulder-clay.

---

[1] Israel Russell,—National Geographic Magazine, May, 1891.

Areal Distribution of Erratics.

Not only are the rocky materials contained in the Drift not arranged in any discoverable vertical order, but well recognized types of rock have a wide areal distribution. All over Lancashire, Cheshire, and Shropshire, Scotch and Eskdale granites are to be found in large boulders now scattered over the surface, while smaller boulders and pebbles of the same rocks are to be seen in the Drift itself. East and west they extend also from the Pennine Chain across Lancashire and Cheshire and along the coast of Wales to beyond Moel Tryfaen, in Carnarvonshire.

If all these boulders have been conveyed to these points by an ice-sheet, some reasonable explanation of how it was done ought to be given.

This hypothetical ice-sheet is supposed to have originated in Scotland, and to have been reinforced by glaciers from the north-west of England and the north-east of Ireland. Its course was over the bed of the Irish Sea to Liverpool Bay, at which place it divided into two lobes, one of which flowed onwards over Cheshire and Shropshire, and the other flowing westward, skirted the coast of Wales. Taking Criffel as the origin of the Scotch granite, it would form the apex of a triangular area over which this granite has been distributed, having a base—measuring east and west along the coast of Wales—as long as its sides.

The divergence of flow from Criffel will thus have been as great s 40 degrees, a very improbable thing to have happened with an ce-sheet traversing a basin fed from three sides. But when we onsider that Lake District granites are found all along the same ase, the improbability becomes to my mind an impossibility; for t would involve, first, a concentration and mixing of the two ifferently-derived rocks on or in the ice-sheet, and their after disribution in a fan-like form. This is omitting from consideration he further difficulty of the Antrim flints and other erratic rocks ound over the same area.

High-Level Sands and Gravels.

Not only does the land-ice theory fail to explain the areal distribution of erratics, but we have the further difficulty to contend with hat they are found at all levels up to 1400 feet above the sea. They are, as already pointed out, proportionally greater in numbers at the top of Tryfaen than in the Drift of the coastal plain of Carnarvonshire. As a question in dynamics it has never been shown what gradient would be required for an ice-sheet from the North hus to overpower the native glaciers of Snowdonia. The Welsh mountains are higher than any in the South of Scotland, so that to overpower the thrust of the ice northwards from a Snowdonian centre, and to deflect it south-westwardly, an enormous pile of snow would have to be concentrated in Scotland. A surface slope of half a degree would mean a depth of snow of over a mile at Criffel, plus he depth of snow on Tryfaen. The gradient of the Welsh ice-sheet, even if the top of Snowdon were bare, would be about 4 degrees from Snowdon to the top of Tryfaen. Putting it in the most favourable light for the land-ice theory, it would appear that even had he snow been two miles thick at Criffel, and in Wales reached only to the top of Snowdon, the Snowdonian glacier would have overcome he northern ice-sheet and have effectually prevented the landing of sea-bottom on a flanking spur of Snowdon, were such an event otherwise possible.

But there yet remains another difficulty; the deposits in question are admittedly *aqueously* deposited, so that on the ice-sheet theory he ice containing these sea-bottom remains must have melted and n such a manner as to have deposited the sands and gravels and boulders in a stratified mass on the summit of a hill 1400 feet above he sea-level. No one has grappled with this hydraulic difficulty. Similar reasoning applies to the Gloppa drift, which is 1100 feet above the sea and over 60 feet thick, probably 100 feet, as it has never been bottomed, and bears in its current-bedded stratification ndubitable marks of aqueous deposition. There still remains a most mportant fact which must not be lost sight of in this connexion, namely, the presence of perfect and delicate shells. Since Mr. Nicholson, F.G.S., made his splendid collection of glacial shells on Gloppa, this difficulty has been emphasized. The fragmentary condition of most of the Drift-shells had been triumphantly pointed to s a convincing proof of the passage of an ice-sheet over them.

Now the odd thing happens that the largest collection of the most perfect shells are found just in the place where they are least wanted on the ice-sheet hypothesis. Obviously a safe means of transport must be provided, and this is supposed to be ensured by the working up of the sea-bottom material into the ice-sheet, and these delicate shells, solidly encased in ice, are pushed safely an unknown distance over the sea-bottom and then uphill and down dale to be eventually melted out and deposited upon the summit of a hill 1100 feet above sea-level.

There is yet another if a minor question of a physical nature that obviously requires answering. If the ice-sheet possessed sufficient power to force sea-bottom 1400 feet up the slopes of Snowdonia and within five miles of its highest centre, why should the snows from the mountains of Denbighshire and Flintshire be sufficient to divert one lobe of it over the plains of Cheshire, and the other along the Welsh coast?[1] Rather one would expect that the whole of Flintshire and Denbighshire would have been overwhelmed with an ice-covering marching irresistibly towards the Midlands.

Nor must we lose sight of the fact that near Macclesfield and on the Three-Rock Mountain, near Dublin, shelly sands and gravels have been found at a level of about 1200 feet above the sea. These places are on the same parallel of latitude and about 190 miles apart. If the transport was by land ice, the ice-sheet filling the Irish Sea must have had here a front of not less extension than 200 miles, and a minimum depth of say 2000 feet; but on this head we have very little to go by. We may very well ask how a snow-field in Scotland of a less width than the distance between these two places, even assisted by the bordering fields of England and Scotland, could have generated a glacier which not only displaced the water of the Irish Sea, but after spreading out 190 miles still maintained such an enormous depth as to be capable of forcing up sea-bottom laterally on either side to the height of 1200 feet; and in the case of the Three-Rock Mountain against the contributory glaciers of Irish origin.

Distribution of the Sands and the Matrix of the Boulder-clay on the Ice-sheet Hypothesis.

If the Drift occupying Lancashire, Cheshire, and Shropshire has been carried there by an ice-sheet it would show in its constitution little or no relation to the water-sheds in which it occurs; whereas, as I have shown, the contrary is the case. The clays would not preponderate as they do in the lower part of the basin of the Mersey, nor would the sands be found lying upon the New Red Marl as they do in Cheshire and Shropshire.

If an ice-sheet had passed over the Red Marl of Cheshire we ought naturally to look for a great mass of Boulder-clays further south; instead of this sands and gravels preponderate. The waste of the New Red Marl of Cheshire has flowed in a northerly direction long its present water-shed lines and this is further indicated by he common presence of gypsum in the Cheshire Boulder-clay.

---

[1] Mr. Strahan shows that the Drift of the upper part of the Vale of Clwyd has travelled North-East.—Memoir of the Geological Survey, Geology of the neighbourhood of Flint, Mold, and Ruthin.

Presence of Materials and Fossils derived from the South-East.

In the Drift gravels at Wollerton, Shropshire, I found numerous flints, as also to the north of the patch of Shropshire Lias, and at Market Drayton in Shropshire. That these flints have travelled from the south-east I have little doubt. Liassic, Gault and Chalk fossils have been recorded in the Gloppa Drift by Nicholson;[1] Liassic fossils by myself at Wollerton, Shropshire. *Waldheimia obovata* is recorded from the Drift-sand at Wellington, Shropshire, by Dr. Callaway. In the Old Gravels above Wigmore Lake, not far from Ludlow, the Rev. T. T. Lewis obtained some specimens of Lias gryphytes (Record of the Rocks, p. 177). Beete Jukes says (Memoir of South Staffordshire Coalfield, second edition, pp. 207, 208) that Chalk fossils often abound in sand and gravel at Wolverhampton, and between it and Shiffnal, and sometimes broken fossils of the Lias and Oolitic formations, and seem therefore rather derived from the east than the north. Mackintosh describes coal found in Drift-sand, near Corwen, which he, with a good show of reason, infers has come from near Ruabon or from east to west. "Mr. Molyneux has noticed what he describes as a remarkable tract of Chalk-flints stretching across the high ground of Hanbury Woodend (north-west of Burton-on-Trent) running east and west" (Deeley, Q.J.G.S., vol. xlii. p. 459). Charnwood Forest rocks are found in the Boulder-clay of Nottingham, and must therefore have travelled in a northerly direction (*ibid.* p. 480).

I have myself found pre-Cambrian rocks of the Wrekin in Boulder-clay immediately to the north of the Wrekin.

This drift of materials is either across or directly opposite to the direction of the supposed flow of the ice-sheet. I have no doubt the list could be much extended, and these facts cannot be reasonably accounted for on the land-ice hypothesis.

The Glacio-Marine or Submergence Theory.

While the land-ice hypothesis, supported by much ingenious reasoning, based upon imagination rather than facts, fails to explain numerous phenomena, the old idea of submergence offers a much simpler and more reasonable explanation of the drift phenomena I have described in these pages.

The dispersion of erratics, the presence of marine shells, the wear of boulders, and the rounding of sand grains, are all consistent with Glacio-Marine deposition. The preponderance of far-travelled erratics in the high-level Marine Drift of Tryfaen is suggestive of the same cause. I have found crystalline schist from Anglesey in this drift in a water-worn condition, but the Lake District and Scotch granites greatly preponderate. Yet Anglesey is directly in the path of the hypothetical ice-sheet, and should therefore have contributed the larger store of rocky materials. The granite centres on the submergence theory would, being at a greater elevation and casting off glacial ice, continue supplying granite, boulders, and pebbles for a much longer period than Anglesey. Thus, although more distant in their derivation, the preponderance of granites on Tryfaen is satisfactorily explained.

---

[1] Mr. Nicholson tells me he found one of the Lias fossils himself in the Drift, and that although the others were found by the workmen, he has no reason to doubt their genuineness.

I have already in various papers expressed my opinion that the Low-level Boulder-clay and sands have been mainly formed in shallow waters when the subaerial denudation of the land contributed largely to their formation.

Their distribution is consistent with this view, but not with the view that the whole of their materials have been pushed along the land from the northwards, and are mainly composed of ploughed-up Irish-Sea bottom. It used to be a principle among glacialists that the proof of any deposit being "ground moraine" was the preponderance of local materials in it. Now the carrying powers of land-ice have been theoretically extended to include almost every glacial deposit in the category of ground-moraine, so that the boulders forming the great bulk of the rocks in Boulder-clay hundreds of miles away from their origin, and among which local rocks may be searched for in vain, form no difficulty to the modern glacialist.

But, say the supporters of the land-ice theory, the high-level drifts are uncommon and sporadic, whereas on the submergence theory they ought to be common and general. I confess myself unable to see, if there be any truth in this argument, why it should not equally apply to the deposits of an ice-sheet. The Drift has been spread pretty evenly and generally over the low-lands, which is consistent with glacio-marine deposition. It has been spread less generally and more irregularly over the hilly districts, but yet much more largely than the land-ice theorists would have us believe. It must be an exceptional thing for shells to be present in these loose deposits, yet nothing that has them not is admitted as marine-drift. Again, on the low-lands numerous artificial excavations are constantly showing us the nature of the subsoil, while on the hills we have to wait for the occasional opening of a slate quarry or a gravel-pit before we can ascertain what the superficial covering is composed of or what its depth is. It was the accident that between 30,000 and 40,000 tons of sand and gravel were required for the Vyrnwy filter-beds that discovered the existence of these extensive and thick beds of sands and gravels with their remarkable molluscous remains, previously unsuspected. I have little doubt that these examples will multiply as further engineering works are carried out. Quarries are not so likely to discover these beds, for quarrymen avoid such places, as the expense involved in removing the "fay," as the overlying loose deposits are called, lead their operations to where there is less cover on the rocks.

Another objection urged against the submergence theory is the supposed impossibility of shells representing such diverse conditions being congregated in one place. Strange to say, Forbes was the first to raise this difficulty with respect to the shells found by Trimmer on *Tryfaen*. As a matter of fact, I have in my collection the whole of he list (except one species) picked off the Crosby shore either by nyself or my sons. Species and genera the most diverse in habitat re thrown up on the shore, and the same may just as readily have appened in the glacial sea in glacial times. Again, it is urged that there are shells whose habitats now are southern, mixed up with boreal types, and that they could not have lived together in the same sea. The only shell of southern type that has anything approaching a wide distribution in the Drift is *Venus chione*, and that is now found living in Carnarvon Bay. The southern types of shell appear to be more frequent (though only two species are recorded from Gloppa) in the High-level sands and gravels than in the Low-level Boulder-clay and sands; and this is consistent with the amelioration of the climate which set in with the submergence. Some Tertiary shells are now only boreal in their habitats, notably *Tellina calcarea*,[1] a common fossil of the Scotch drift; yet it hardly would be contended that any part of the Tertiary period was colder than the present. The fact is we are ignorant of the causes that govern the distribution of molluscs, and are not in a position to say that it is solely temperature. At Cape Cod, in latitude 42°, arctic and southern forms are now dredged up alive from the same bottom. Finally, the great majority of the mollusca of the Drift are now found living in the Irish Sea. Not only so, but the most common species of the Drift of the north-west of England are the most frequently found now on the sandy shores of Lancashire. If a few boreal forms were introduced among the living molluscous fauna of the Irish Sea, and two or three southern types less freely, we should have a pretty close reproduction of the fauna of the Drift. The shells of the Drift are little distinguishable in condition from those of recent molluscs, which I believe are lineal decendants of those that occupied the Irish Sea in Glacial times.

The remarkable equality of maximum level of the high-level sands and gravels with shells scattered over an area 190 miles wide from east to west points towards deposition by the sea rather than by land-ice.

With this I must for the present conclude, for though I have far from exhausted the illustrations and arguments gained in the field during the last twenty years, the reasonable limits of space prevent me from expanding them. Enough, I trust, has been said to show that the Glacial deposits, being fairly interrogated, speak strongly in favour of a glacio-marine origin.

VI.—A Sand-Pit at Hill Morton, near Rugby.

By the Rev. P. B. Brodie, M.A., F.G.S.

DURING a recent visit of the Warwickshire Naturalists' and Archæologists' Field Club to Rugby, a very interesting section was examined at Hill Morton. It consists, for the most part, of brown and light-coloured sands, exposed near the London and

---

[1] "Occurs in every Tertiary bed up to the Red Crag" (Jeffreys, British Conchology, vol. ii. p. 390).

North-Western Railway, at least 50 feet thick, often false-bedded, the laminæ of deposition being very irregular, interspersed here and there with numerous small pebbles, many of which are sandstone, none very large, though all are more or less rounded, and including much flint. Amongst these were many Lias Gryphææ (chiefly *G. incurva*), and some Cretaceous, Oolitic and Liassic pebbles with occasional fossils; but apparently not many ancient rocks, some of which may possibly be Carboniferous. There are also here and there traces of Carbonaceous matter. The interest in the section consists in the accumulation of such a mass of such sand which occupies a ridge of considerable extent both in length and breadth, on high ground, and is seen at other places in and near the village, and can hardly be considered to belong to the *Drift* properly so-called, and might almost be supposed to be referable to some later Tertiary deposit just anterior to the earliest Drift epoch. No recent shells of any kind were noticed, so that it is impossible to say whether the sand was fluviatile or marine.

It is not easy to determine whence such a mass of fine sand was derived, though it may perhaps have originated from the denudation of some of the sandy beds of the Middle Lias not far off or from some of the more arenaceous Oolitic rocks. If, which is not improbable, the Chalk and Greensand formerly extended over this area, and have since been entirely removed, the Cretaceous sands would have supplied ample material. Coarse Drift also seen elsewhere in the same position, but quite distinct from the sand below, occurs at the top overlying the sand.

As this section has not been recorded in the Geological Survey Memoir of the District, it seems to be worthy of notice.

REVIEWS.

I.—The Great Earthquake of Japan, 1891. By Professor John Milne, F.R.S., F.G.S., and Professor W. K. Burton, C.E. Illustrated by 29 Plates and a Map of Japan prepared by K. Ogawa. Long folio, pp. 71. (Lane, Crawford, & Co., Yokahama; and E. Stanford, Charing Cross, London. Price £2 2s.)

To Professor John Milne belongs the credit of placing the study of seismology in Japan upon a sound scientific basis. By his earnestness and enthusiasm he created the Seismological Society of Japan, which has already published sixteen volumes of Transactions. He has induced the Japanese Government to establish stations of observation in various parts of the Empire and to have notice of all shocks telegraphed to Prof. Milne at Tokio to be duly recorded and studied. Largely at his own expense, and aided by grants from the British Association, he has set up seismographs invented by himself and Mr. Gray, in Tokio and other places. He has spared neither labour nor expense to carry on his researches, and the record of the great Earthquake of last year is now presented to us as a handsome album, measuring 16 inches by 11 inches, with text by himself and Prof. W. K. Burton, illustrated by thirty plates reproduced from actual photographs, vividly portraying the scenes of this terrible calamity, each plate accompanied by descriptive letterpress. The following extracts are taken from the authors' introduction:—

"Japan is a land of Earthquakes and Volcanoes. Every year its inhabitants are shaken by at least five hundred shocks, and at intervals—several of which fall within the memory of the living—some part or other of the Empire is visited by a terrible catastrophe.

"When nature thus exerts itself cities are rocked like ships upon the ocean, and it is some time before equilibrium is restored. There is a mighty effort, as if a mountain range had escaped the pressure that held it in its crumpled form, and the country is suddenly thrown into the most violent oscillation. Complete relief, however, is not obtained at once; and, for some months, minor yieldings announce themselves with subterranean thunderings and smaller shakings on the surface. In these years one or two thousand shakings are added to the average five hundred."

"When we are not shaken by Earthquakes, certain sections of the country are threatened by volcanoes. Only a few years ago a terrible explosion took place on the side of the grass-covered Baudaison, and in less than ten minutes a tract of country measuring thirteen miles by ten was submerged beneath a sea of earth and boulders at least one hundred feet in depth. Hamlets and farms were buried, and nearly 600 people lost their lives."

"In Japan there are at least three lines of weakness through which volcanic forces have forced openings, and around these the ejected material has built up cones. The first of these lines—which is at least 1000 miles in length—comes from Kamchatka through the Kuril Islands and Yesso down Nippon. Here it is met by a second line about 1500 miles in length, almost at right angles, which runs through the Bonin Islands to the Ladrones in the Pacific. The third comes up from the Philippines through Formosa, to the centre of Kinslim, where it terminates in Asosan, a volcano with a ring-formed crater ten miles in diameter. In the middle of Japan there are no volcanoes, but severe Earthquakes have been as frequent there as they have been in other portions of the country. The greatest frequency is along the east coast; and these disturbances, which are of daily occurrence, do not come from the volcanoes, nor does their frequency show any relationship to volcanic action as exhibited at craters." . . . .

"The vapour to which we now look as being a possible cause of Earthquakes is that of water. By capillary action, water soaks downwards to heated regions, and the resulting steam we know to be the motive power at our volcanoes. The earth's crust not being sufficiently strong to withstand the increasing subterranean pressure, whole mountains have been dissipated as dust and boulders, and although a great portion of the force of the explosion has been spent in the creation of air-waves, earthquakes of considerable magnitude have been produced. Similarly we can conceive of subterranean explosions as the producers of earthquakes. Certainly the fact that many earthquakes occur in volcanic countries, and near the ocean where we therefore have both heat and moisture, support such a view."

. . . .

"The great disturbance which we illustrate, occurred about the centre of Japan, in the Prefectures of Aichi and Gifu. The severely shaken district, in many portions of which the destruction of buildings and engineering works was complete, extends over 4200 square miles. The area in which brick buildings were affected reached as far as Tokyo to the east, and Kobe to the west, or over an extent of country of 4400 square miles. The disturbance was, however, felt from Sendai in the north to Nagasaki in the South, or over an area of 92,000 square miles, and had Japan been surrounded by land instead of water, the land area shaken would have been about 400,000 square miles, Delicate instruments may possibly have been affected at the Antipodes. Effects were noticed in Shanghi."

. . . .

"If we were asked whether the Gifu-Nagoya plain was a place where earthquakes were frequent, we must reply in the affirmative. In Japan there are some seven hundred stations where earthquakes are observed, and from several of them situated on the Gifu plain we find that, in the six years from 1885 to 1890 the number of shocks recorded in that district were respectively, 9, 4, 10, 12, 15, and 36; whilst in the corresponding years in Tokyo, where accurate records are taken with seismographs, the numbers were 51, 55, 80, 101, 115, and 93."

. . . .

"Standing on one of the hills, which form the margin of the devastated area, a vast plain, covered with rice-fields dotted with clumps of trees and hamlets, and streaked with the silvery bands of the four great rivers which cross it, stretches as far as eye can reach. From the western side of this plain—which supports a population of perhaps 800 to the square mile—one sees towards the south the islets and promontories of Owari Bay, before one the turrets of the castles rising through the blue smoke of Nagoya and Ogaki, beyond which comes the gently sloping uplands forming foothills to dark green mountains."

"The Nagoya-Gifu plain is one of Japan's great gardens, but it has been devastated. A disturbance occurred in the Mino mountains, and at once an area, greater than that of the Empire of Japan, became a sea of waves, the movements being magnified on the surface of the soft alluvial plains. In Tokyo, more than two hundred miles from the centre of the disaster, the ground moved in long easy undulations, producing in some persons dizziness and nausea, the movement being not unlike what we might expect upon a raft rising and falling on an ocean swell. Near to its origin the waves were short and rapid, cities were overturned, the ground was fissured, small mud volcanoes were created, and the strongest engineering structures were ruined. About ten thousand people lost their lives, fifteen thousand were wounded, and one hundred thousand houses were levelled with the plain, whilst almost every building in the Meozoseismal area was shattered. From the effects that have been produced upon huge engineering structures we must conclude that the earth-movements in Mino at the time of the great earthquake were at least equal to any movements recorded in the annals of seismology."

. . . .

A glance at the fine series of plates, reproduced from actual photographs (all executed in Japan by native artists), conveys a wonderful and realistic idea of the destruction wrought by this earth-movement on the works of man, and one can more easily realise what would be the effect of even a slight earth-movement to such a city as London with its thousands of houses, crowded upon one comparatively small area, and its vast and complex system of drainage, and gas and water-mains, to say nothing of its underground railways burrowing even beneath the Thames! How thankful ought we to be to the Japanese Government who have, by their earnest efforts to do honour to Prof. Milne, succeeded in detaining him upon their hospitable, though tremulous, shores; for had he decided to pay the same careful attention to the seismology of this country, our lives would have been passed in a continual state of anxious unrest, hoping for the best, yet fearing the worst continually.

H. W.

II.—Das Norddeutsche Unter-Oligocän und seine Mollusken-Fauna. Von A. von Koenen. Lieferung III. (Abh. Geol. Specialkarte v. Preuss. u. d. Thüringischen Staaten, Band X. Heft. 3, Berlin, 1891.)

THE third part of this valuable work on the Mollusca of the Lower Oligocene beds of Northern Germany is devoted exclusively to the consideration of the Naticidæ, Pyramidellidæ, Eulimidæ, Cerithidæ, and Turritellidæ.

Of the Naticidæ, Professor von Koenen recognizes four genera—*Natica*, *Naticina*, *Ampullina*, and *Sigaretus*.

The Pyramidellidæ mentioned include the genera *Syrnola*, *Eulimella*, *Odontostoma*, and *Turbonilla*. It has recently been shown that *Syrnola*, A. Adams, 1862, is synonymous with *Obeliscus*, Humphrey, 1797, and the latter name, therefore, is to be preferred.

The Eulimidæ described comprise the genera *Eulima* and *Niso*.

The Cerithidæ occupy a large section of the work, and the peculiar manner in which the author has dealt with this portion of his subject is worthy of note. He recognizes the fact that the genus *Cerithium*, as usually understood by the older malacologists, includes a variety of diverse forms, many of which have but little in common with the type of the genus, and, years since, were separated from it as being distinct genera; yet he calls them all *Cerithium*. Of these, *Bittium*, *Cerithiopsis*, and *Lovenella* occur in the beds in question. The author seems to be quite aware of the existence of these newer generic names, and groups the species together accordingly. Thus, the genus *Bittium*, Gray, is said to be represented by *Cerithium granuliferum*, v. Koenen. Why not call the mollusc *Bittium granuliferum*? The name *Lovenella*, Sars, 1878, should be replaced by *Cerithiella*, Verrill, 1882, the first-mentioned being pre-occupied by *Lovenella*, Hincks, 1868. The other genera of the Cerithidæ mentioned by the author are *Triforis*, *Aporrhais*, and *Mesostoma*, though why the two last mentioned are so grouped we are at a loss to understand. *Aporrhais* does not in any way resemble any member of the Cerithidæ with which we are acquainted, and it is usually placed in the vicinity of the Strombidæ, near *Rimella* and *Rostellaria*—by some authors it is included in the Alata. The name *Mesostoma*, Deshayes, 1861, is occupied by Ant. Dujès, 1830, and even if it were not, its true name by priority should be *Cerithioderma*, Conrad, 1860. Moreover, it is now usually classed with the Trichotropidæ.

Of the Turritellidæ, Prof. von Koenen recognizes the genera *Turritella*, *Mathilda*, *Scaliola*, *Vermetus*, and *Siliquaria*. He includes the Scalaridæ as a sub-family of the Turritellidæ! *Cirsotrema* and *Acrilla* are mentioned as sub-genera, though of what genus, or genera, the author does not very clearly show. The name *Scalaria*, Lamarck, 1801, is used instead of *Scala*, Humphrey, 1797; the latter has been preferred for some time in America, and adopted in recent works in this country. *Crassiscala*, *Clathroscala*, and *Acirsa* occur, and together with the sub-genus *Acirsella* complete the list. The inclusion of the Scalaridæ (or rather Scalidæ, as they should be termed) amongst the Turritellidæ is much to be regretted in face of the writings of M. de Boury and others, on the systematic position of the group.

In spite of these shortcomings, however, the work will be welcomed by all malacologists and geologists who desire to become more perfectly acquainted with the fauna with which it deals. The large number of new specific forms described, and the careful manner in which they have been diagnosed and illustrated, are features the value of which must not be overlooked. G. F. H.

III.—BEITRÄGE ZUR KENNTNISS DER FOSSILEN RADIOLARIEN AUS GESTEINEN DER TRIAS UND PALÆOZOISCHEN SCHICHTEN. Von Dr. RÜST IN HANOVER. Palæontographica, Bd. XXXVIII., 3–6 Lieferung, März, 1892; pp. 107–192. Mit. Taf. VI.–XXX.

CONTRIBUTIONS TO THE KNOWLEDGE OF FOSSIL RADIOLARIA FROM THE TRIASSIC ROCKS AND FROM PALÆOZOIC STRATA. By Dr. RÜST.

DR. RÜST'S researches on the Radiolaria in the Lower Mesozoic and the Palæozoic strata have proved as fruitful as those which he has previously made on this group in the Cretaceous and Jurassic rocks. In this memoir no fewer than 247 species of Radiolaria from the Palæozoic, and 20 species from the Triassic rocks, are described; a remarkable result when it is considered that up to two years since these organisms were scarcely at all known in Palæozoic strata. The Radiolaria mainly occur in jaspers, chert or hornstone, siliceous shales and slates, and siliceo-calcareous beds; but in the numerous Palæozoic limestones examined by the author, they are extremely rare and in bad preservation. In some of the siliceous rocks they are so abundant as evidently to form the main portions of the substance of the rock; as a rule they are, however, too poorly preserved to permit of specific determination; but here and there specimens are met with, usually in the form of hard nodular concretions containing phosphatic, carbonaceous and manganese ingredients, in which the structural details of the Radiolaria are wonderfully shown, not infrequently owing to their being stained by these accessory materials. Strange to say, these Palæozoic Radiolaria are in better condition than any yet known from Mesozoic rocks; and they are generally larger and possess stronger and more complicated tests than the Mesozoic species, thus more nearly resembling Tertiary and living forms. In the radiolarian-bearing rocks there are, occasionally, sponge-spicules, and in some of Silurian age, fragments of graptolites, but calcareous fossils are absent.

The Triassic Radiolaria were principally obtained in beds of chert of Middle and Lower Muschelkalk age, in the Tyrol, and at Felsö Eörs in Hungary. In the Palæozoic rocks the greatest development of Radiolaria is met with on the lowest horizon of the Carboniferous limestone, beginning at the Culm and reaching downwards to the Upper Devonian. In the Harz, Hessen and Waldeck, they are present in dark carbonaceous siliceous shales, jaspers and chert, they also have been met with in the Ural and possibly also in Sicily, in rocks of the same horizon. From these various localities 155 species have been described. In the Upper Devonian rocks of the Hartz the Radiolaria occur in siliceous shales containing manganese, but without carbonaceous material; whilst in the Lower Devonian of the Ural they are present in red jasper, and on the same horizon in Hessen in siliceous shale, which the author considers a true radiolarian mud. Altogether from Devonian strata 64 species have been recognized.

In rocks of Ordovician or Lower Silurian age Radiolaria occur in siliceous shales at Langenstriegis, in Saxony; Bohemia; Scotland; and more especially at Cabrières in Languedoc, where they are excellently preserved in phosphatic concretions loosely imbedded in the shales. No comparison is made of the forms in the Scotch chert with those from other localities, and no mention whatever of those described in a paper published nearly two years since. In all 26 species are described by the author from Lower Silurian beds; with the exception of three forms, they have been derived from the Cambrières concretions. At a still lower horizon, in the Cambrian rocks of Sonneberg, in Thuringia, Radiolaria are present, but their specific characters cannot be distinguished.

Out of 109 genera in which these Palæozoic and Triassic forms have been ranged, but two only are new. The 247 Palæozoic species fall under the following orders in Haeckel's classification of the group: Spheroidea, 81 sp.; Prunoidea, 48 sp.; Discoidea, 52 sp.;

Cyrtoidea, 55 sp.; Stephanoidea, 8 sp., and Larcoidea 3 species. Only 13 species are common to Jurassic and Cretaceous rocks.

The author seems justified in considering these siliceous radiolarian rocks as deposits of deep-sea character, comparable with the radiolarian oozes of the present oceans, and it remains for those who oppose this view to show wherein the difference consists.

In the accompanying 25 plates excellent illustrations of the new forms are given, enlarged to the scale of 300–450 diameters. It would have been better if the scale of enlargement had been given with each figure, for comparisons made with the measurements given in the text show that in some cases they are drawn on a much smaller scale than that stated.

Dr. Rüst deserves the thanks of all palæontologists for his arduous researches on the Mesozoic and Palæozoic Radiolaria, which are completed with this memoir. Not the least difficulty in this pursuit is to obtain material, for siliceous rocks, like those containing Radiolaria, have until lately been considered as barren of fossils, and consequently have been unnoticed by collectors. The preparation of microscopic sections likewise involves considerable labour, and the author states that 5000 were made for the purpose of this Memoir. The study of these small organisms is only now beginning, and judging from the fact that in a single hand-specimen of rock in which the forms are well preserved, fifty new species may be found, there can be little doubt that in number and variety fossil Radiolaria will prove in nowise behind those living at the present day.

G. J. H.

IV.—ANZEICHEN EINER INTERGLAZIÄREN EPOCHE IN CENTRAL-RUSSLAND. (Umgebungen des Dorfes Troïzkoje, Gouv. Moskau.) Von N. KRISCHTAFOWITSCH. Bulletin de la Soc. impériale des Naturalistes de Moscow, N.S. Tome IV. 1890, No. 4, pp. 527–547.

INDICATIONS OF AN INTERGLACIAL PERIOD IN CENTRAL RUSSIA. (Village of Troizkoje, near Moscow.) By N. KRISCHTAFOWITSCH.

IN the high banks on the right side of the Moskwa river, at the village of Troïzkoje, about 10 kilomètres from Moscow, there are exposed some beds of lacustrine derivation containing numerous plant and animal remains, including bones of the Mammoth, which are covered by typical Glacial deposits, and on this account have been supposed to be of pre-Glacial age, and compared with the Forest Bed of Norfolk. This lacustrine formation has been studied by several well-known Russian geologists during the last fifty years, and lately the author of this paper, accompanied by Professor and Madame Pavlow, made a more thorough examination of the locality, and by removing the débris at the base of the river bank ascertained that the lacustrine beds rested on glacial materials of the same character as those above them, thus showing that they were inter-Glacial instead of pre-Glacial in age. It had been assumed by previous writers that the fresh-water beds rested directly on the Upper Jurassic sandstones which form the bed-rock in this region.

The following gives the succession of the beds as shown in the river bank and on the sides of a lateral ravine:

(*a*) Surface layer of humus.
(*b*) Yellow sand with thin partings of clay, 1½ m.
(*c*) Yellowish-grey sands with erratic blocks of Northern origin, from Finland, Olonetz, &c., 3½ m.
Lacustrine deposit. (*d*) I. A reddish-brown clay bed, becoming yellowish-grey below.
  II. Greenish-brown and grey beds.
  III. Very sandy, dark-green and grey beds with layers of turf.
(*e*) Thin layer of reddish-brown loam.
(*f*) Reddish-brown, yellow, and clear sands with erratics of Northern rocks; in the upper portion sandy concretions with crystalline erratics.
(*g*) Coarse glacial sand.
(*i*) Red ferruginous sandstone with erratics of crystalline rocks.
(*k*) Jurassic beds (?) upper Volga horizon.

The lacustrine beds are shown for a distance of about 100 mètres, and they have a maximum thickness of about 12 mètres. In some places organic materials are so abundant in the beds that they resemble lignite, and are readily combustible. The plant-remains in them include leaves of *Quercus, Salix, Alnus, Betula, Corylus, Acer, Pinus sylvestris, Nuphar luteum,* and mosses. Fresh-water species of diatoms are also extremely abundant The plants are similar to those now living in the same area, but some forms are more abundant than at present, which leads the author to conclude that the climate of that time was somewhat milder and moister than that of to-day. The animal-remains consist of wing-cases of beetles, shells of *Anodon,* and teeth, bones and scales of fishes, principally pike and perch. The Mammoth skeleton was found in an upright position; partly in the middle (II.) and partly in the lower bed (III.) of the deposit. From the remains it would appear that the flora and fauna of these inter-Glacial beds were substantially the same as at present, and that only the large Mammoth has disappeared.

The author has found traces of similar lacustrine materials at a locality 3 kil. distant from Troïskoje, and in the river banks of other places in Central Russia deposits are known which will probably prove to be of the same age as those described.

The evidence of the deposition of these beds and of a temperate climate, in a period intermediate between the formation of beds of glacial character, seems clear and indisputable, and there can be no doubt of their similarity to the inter-Glacial beds of Germany and Western Europe.

G. J. H.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—May 25th, 1892.— W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "On *Delphinognathus conocephalus* (Seeley) from the Middle Karoo Beds, Cape Colony, preserved in the South-African Museum, Capetown." By Prof. H. G. Seeley, F.R.S., F.G.S.

The skull described in this paper is believed by Mr. T. Bain to have been collected by himself near Beaufort West. The preservation of the specimen leaves something to be desired, but notwithstanding defects the skull belongs to a most interesting Anomodont, indicating a new family of fossil Reptilia.

The skull is fully described in the paper, and its relationships are discussed. The author has already given reasons for regarding *Ælurosaurus felinus*, *Lycosaurus curvimola*, and their allies as referable to a suborder *Gennetotheria*, which is nearly related apparently to the *Pelycosauria*, and lies midway between the typical *Theriodontia* and the *Dicynodontia*. It is to this suborder that *Delphinognathus* may be referred, though it forms a family-type distinct from the *Ælurosauridæ*, distinguished by the conical parietal with a large foramen, the anterior supra-condylar notch in the squamosal bone, and other modifications of the skull and teeth.

2. "On Further Evidence of *Endothiodon bathystoma* (Owen) from Oude Kloof, in the Nieuwveldt Mountains, Cape Colony." By Prof. H. G. Seeley, F.R.S., F.G.S.

Two bones found by Mr. T. Bain at Oude Kloof, consist of the left ramus of the mandible and what the author regards as the left squamosal bone of *E. bathystoma*. The small cranial fragment preserved shows that the cerebral region probably conformed to the type of skull seen in some of the Dicynodonts.

A description of the remains is given, and the author notices that the form of the articular condyle indicates a difference from *Dicynodontia* and all other *Anomodontia* hitherto described; it implies an oblique forward inclination of the quadrate bone—a character important in defining the suborder *Endothiodontia*. All the characters of the dentition of the animal suggest near affinity with the *Theriodontia*, especially the long lancelolate teeth strongly serrated.

3. "On the Discovery of Mammoth and other Remains in Endsleigh Street, and on Sections exposed in Endsleigh Gardens, Gordon Street, Gordon Square, and Tavistock Square, N.W." By Henry Hicks, M.D., F.R.S., Secretary of the Geological Society.

In this paper the author gives a description of the deposits overlying the loam in which the remains of the Mammoth and other animals were found in Endsleigh Street, N.W. Under about 6 feet of made ground there was about 10 feet of a yellowish-brown clay containing flints and much 'race.' Below the clay there was about 5 feet of sand and gravel, and under this about 1 foot of clayey loam, in which most of the bones were embedded. This loam contained many seeds, recognized by Mr. Clement Reid, F.G.S., as being those of plants usually found in marshy places or ponds and having a range at present from the Arctic Circle to the South of Europe. A list of the bones found is given by Mr. E. T. Newton, F.G.S., of the Museum of Practical Geology, Jermyn Street, who describes them as being those of one full-grown Mammoth, of another about half-grown, of the Red Deer, the fossil Horse, and of a small rodent.

The author gives sections through Endsleigh Street and along the southern side of Endsleigh Gardens, and shows that where the bones were found there was a distinct valley in the London Clay, running in a direction nearly due north and south, the inclination of the valley being towards the north. The London Clay reached nearest to the surface towards St. Pancras Church and in Upper Woburn Place, the total thickness of the overlying deposits and the made ground there being only about 12 feet.

Other sections, given along the southern side of Tavistock and Gordon Squares and through Gordon Street and the western side of Gordon Square, show varying thicknesses of the deposits, overlying the uneven floor of London Clay, of from 16 to 21 feet; the greatest thichness here is found at the north-western corner of Gordon Square.

Seeds were also discovered in a loam near the bottom of Gordon Street, at the same horizon as that containing the mammalian remains, and some shells were found in a band of sandy clay under a calcareous deposit, about half-way down the western side of Gordon Square.

The Author says that the deposits above the mammaliferous loam overlying the London Clay in this area cannot be classed as post-Glacial river-deposits, but must be considered as of Glacial origin. The animals, therefore, which evidently died on the old land-surface where their remains were found, lived there early in the Glacial period.

4. "The Morphology of *Stephanoceras zigzag.*" By S. S. Buckman, Esq., F.G.S.

Material which has come into the author's possession throws light on the developments of *Stephanoceras zigzag*, and such developments seem to supply missing links in the connexion of Bathonian and Bajocian species.

The author separates the developments of *S. zigzag* into three series, and discusses the allied forms of each.

II.—June 8th, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:

1. "The Tertiary Microzoic Formations of Trinidad, West Indies." By R. J. Lechmere Guppy, Esq. (Communicated by Dr. H. Woodward, F.R.S.)

After giving an account of the general geology of the island, and noticing previous memoirs devoted to that geology, the author describes in detail the characters of the Naparima Beds, to which he assigns an Eocene and Miocene age. He considers that the Nariva Marls are not inferior to but above the Naparima Eocene Marls, and are actually of Miocene date.

Details are given of the composition and characters of the 'argiline,' the foraminiferal marls occasionally containing gypsum, and the diatomaceous and radiolarian deposits of Naparima.

The Pointapier section is then described, and its Cretaceous Beds considered, reasons being given for inferring that there was no break between the Cretaceous and Eocene rocks of the Parian area.

Detailed lists of the foraminiferal faunas of the marls are given, with notes.

The author observes that the Eocene molluscan fauna of Trinidad shows no near alliances with other known faunas, thus differing from the well-known Miocene fauna of Haiti, Jamaica, Cuba, Trinidad, and other localities. Only one mollusc is common to the Eocene and Miocene of the West Indies. The shallow-water foraminifera, are found in both Eocene and Miocene, whilst the deep-water foraminifera are nearly all of existing species.

It would appear that during the Cretaceous and Eocene periods a sea of variable depths (up to 1000 fathoms) occupied the region now containing the microzoic rocks of Trinidad, whilst a mountain-range (which may be termed the Parian range) extended continuously from the north of Trinidad to the littoral Cordillera of Venezuela, forming the southern boundary of the Caribbean continent, and possessing no large streams to transport mechanical sediment into the Cretaceo-Eocene sea which opened eastward into the Atlantic.

An Appendix by Mr. J. W. Gregory deals with the microscopic structure of the rocks.

2. "The Bagshot Beds of Bagshot Heath (a Rejoinder)." By the Rev. A. Irving, D.Sc., F.G.S.

The author maintains that the northerly attenuation of the Lower Sands and of the 'green-earth series' between the two principal brick-clays of the district is an established fact. He insists on the value of the Wellington College well-section as a vertical datum-line, on account of its proximity to the northern outcrop (which is not the case with the Goldsworthy section). But it does not stand alone, for the well-section at the Bagshot Orphan Asylum gives practically the same sequence, and affords strong evidence of the thinning northward of the above-named deposits. (Other instances cited by the author in 'Recent Contributions,' etc., corroborate the reading he has adopted.) The Goldsworthy section itself lends strong corroborative evidence as to the value of the College well-section. The evidence of attenuation in the direction of Bracknell the author reserves for the present. In his paper published in the February number of the Society's Journal for the current year, Mr. Monckton ignores the determinative value of stratigraphical alignment of the clays claimed as the basal clays of the Middle group with clays of the same character seen cropping out from below the 'green-earth series' at no great distance. This evidence of stratigraphical alignment must be allowed due weight when set against evidence derived from such lithological characters as the presence of pipe-clay, mica, and false-bedding. The author considers that the argument as to the fossil evidence is over-stated in the above-mentioned paper.

After criticizing some of the remarks in Mr. Monckton's paper, the author adds some notes on the sections at Farley Hill, Bearwood, and Wokingham.

3. "Notes on the Geology of the Nile Valley." By E. A. Johnson Pasha and H. Droop Richmond, Esq. (Communicated by Norman Tate, Esq., F.G.S.)

The rocks on either side of the Nile are chiefly Eocene (and Cretaceous?) from Cairo to Esneh; south of this is sandstone, which the authors believe to be Carboniferous and to yield possible indications of coal, reaching to near Assouan, where it meets the granite and basalt of that region; a few miles south the sandstone begins again and continues to Wady Halfa, broken only by granite dykes.

The granite is intrusive into and alters the sandstone, whilst the latter reposes upon the basalt, and in some cases was deposited against upstanding basaltic masses. Unmistakable lavas occur near the Nile E. of Minieh and W. of Assiout.

A description of some remarkable faults is given, and various minerals are noticed as occurring in the sedimentary rocks and the bed of an ancient river.

CORRESPONDENCE.

PERMIAN IN DEVONSHIRE.

Sir,—After a careful perusal of the article on this subject in this month's Number of the present volume (pages 247–250) by Mr. W. A. E. Ussher, I am rather at a loss to see the actual drift of it. The author shows he is acquainted with several foreign geologists; and that he has seen the German Rothliegendes; he quotes opinions of one or two foreigners (notably Herr von Reinach) which corroborate my assignment in 1888 of the breccia-series of Devon to the age of the Rothliegendes (pp. 247, 248); and a little further down (p. 248) he puts forward a "probable correlation" of the Devon series of Teignmouth and Dawlish with rocks of the Nahe district, which agrees in all essential matters with the parallelism drawn in my papers (in the Q.J.G.S. of 1888 and 1892) between the Devon breccia-series and the Rothliegends of the Thüringen country, and of the country further east in Central Germany, particularly in the Gera district,—a parallelism based on previous first-hand knowledge of the German series. I commend these regions with that around the Hartz to any one who wishes to know the German Rothliegendes.

While, then, I entirely agree with Mr. Ussher that "no correlation framed on a partial or even intimate acquaintance with the *South Devon coast-section only* can be regarded as conclusive," I must ask you to allow me to remind readers of the Geol. Mag. of the two papers published by me in the year 1884, (1) "On the Dyas and Trias of Central Europe" (Q.J.G.S.), (2) "On the Permian-Trias Question" (Geol. Mag.); papers, of the existence of which Mr. Ussher could not have been ignorant at the time he penned the paragraph which opens with the above-quoted remark (pp. 248, 249), and of the value of which M. Jules Marcou expressed his strongest appreciation to me at the time.

The information given on p. 248 respecting the contemporaneous igneous rocks of the Nahe country adds little or nothing to our previous knowledge of them, since we read in Credner's 'Geologie' (6th edition, 1887), "The two lower groups [of the Rothliegendes of the Saar-Rheingebiet] are grouped by E. Weiss as Carboniferous Rothliegendes, described by von Dechen as Carboniferous rocks poor in coal-seams. During their deposition very numerous eruptions of felsite-porphyry, melaphyre, palatinite, and porphyrite occurred, and formed dykes, intrusive layers, and tabular lava-flows (plattenförmige Effusionsschichten) between the sedimentary rocks" (p. 516). Further details of the stratigraphy are also given (*loc. cit.*).

I am glad to find my contention in the paper which appeared last February (Q.J.G.S.) supported by the establishment by Professor Bücking of the lithological identity of some of those rocks with igneous rocks of the Devon Permian; although, as an argument based on the assumption of a strict temporal order of succession among igneous rocks, it has not much weighed with me. I must remind Mr. Ussher that those, who know how the basis of our classification of the *Midland* Permian and Trias was laid for us by the labours of Prof. Hull in former years, can hardly be expected to admit his statement on p. 249, that "the Midland sections owe their importance as a basis for correlation entirely to the merits of the assumed correctness of their classification with reference to the German types." The fact that the Devon and Midland areas were at the time disconnected does not affect the question, as a careful study of my papers, and that of Prof. Hull (1892), will make clear to any candid mind; papers based on observations by no means limited to the coast-section.

Wellington College, Berks. A. Irving.
13th June, 1892,

CONE-IN-CONE STRUCTURE.

Sir,—Mr. Young's statement that "The apices are invariably turned to the under or lower side of the structure while their bases are as invariably directed to the upper surface,"[1] is certainly not of universal application. In addition to examples instanced by Mr. Harker,[2] from the Lingula Flags and Lias shales, I may mention specimens of my own of concretions from the pencil slates in Swindale and from Carboniferous shale in Northumberland, which exhibit a similar radial arrangement of the cones. But the beds which afford the most striking refutation of Mr. Young's statement are the Coal seams, for it is in these beds that the structure is by far the most extensively developed portions of some seams several inches in thickness being made up of these cones. Examination of numerous specimens from the coal fields of Durham and South Wales show two systems of arrangement of the cones—one, where the cones have formed at right angles to certain laminae of deposition and on *both* sides of such laminae which are $\frac{1}{8}$–1 inch in thickness, so that the apices of the cones above point downwards, whilst those below point upwards, both sets of cones having evidently formed outwards from the same set of laminae. But the commonest disposition of the cones, especially in the Durham seams, is *parallel* to the bedding planes, and although the apices often run for some distance pointing in a constant direction, cases are of frequent occurrence where the bases of the cones start back, the apices being directed away from each other.

[1] Geol. Mag. for March, 1892, p. 138. [2] *Op. cit.* May, 1892, p. 240.

I do not see how Mr. Young's theory of the origin of Cone-in-cone structure by the upward escape of gases bringing up from below successive layers of plastic mud can possibly apply to the bulk of such concretions. E. J. Garwood.

FLEXIBLE SANDSTONE.

Sir,—I have read an interesting paper by Mr. G. W. Card, A.R.S.M., in the March number of the Geological Magazine "on the flexibility of rocks," and as there have of late been several allusions to this subject in the press. I venture to bring the following facts under your notice.

About eleven years ago a friend presented me with a piece of flexible sandstone which he had brought from India. I, in turn, gave the specimen to my friend and chief, the late Mr. C. S. Wilkinson, F.G.S., Government Geologist of N.S.W.

Mr. Wilkinson was greatly interested in the peculiarities of the stone, and after devoting some time to their investigation he informed me that he felt convinced that the flexibility was due to the presence of interstices between the grains of sand, and to the interlocking of the latter. He believed the interstices to be due to the shrinking of the cementing clay by loss of moisture, and in order to test his theory he immersed the specimen in water, with the result that after some time it became rigid. After again thoroughly drying the stone he found that its flexibility was completely restored.

Mr. Wilkinson was in the habit of showing this specimen and explaining the cause of its flexibility to visitors for some years before Mr. Oldham's paper on the Delhi sandstone was written, and there is no doubt in my mind that to him (Mr. Wilkinson) is due the credit of first recognising the cause of the flexibility of the Indian sandstone. Edward F. Pittman, A.R.S.M.

Geological Survey, N. S. Wales, Government Geologist.
Department of Mines, Sydney, *9th May*, 1892.

OBITUARY.

STEPHEN AUSTIN.

Born 1804. Died 21st May, 1892.

By the death of Mr. Stephen Austin, in his 88th year, the Editor of this Journal has been deprived of an old and much valued friend, whose name must also now be familiar to all his Contributors as the printer of the Geological Magazine, since December 1865. The first two volumes (1864–65) were printed by Messrs. Spottiswoode & Co.; but the last twenty-seven volumes have been issued from the printing press of the well known firm of Messrs. S. Austin & Sons, Printers, Hertford, the excellence of whose work has largely contributed to maintain the reputation of this Journal during more than a quarter of a century that it has been in their hands.

This noted firm has been established in Hertford since 1768, having in that period passed through the hands of four generations of "Stephen Austins."

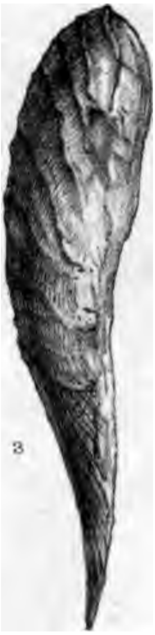
Mr. Austin's name will be best known to the world at large as one of the first and most celebrated printers of Oriental Literature.

Mr. Austin and his father were the appointed printers and booksellers to the East India Company's College, the work of which while Haileybury was being built, was carried on at Hertford Castle. Mr. Stephen Austin retained that position until the Company was dissolved in 1858; and it was under the auspices of the authorities of that institution that he commenced the printing and publishing at Hertford of works in various Oriental languages. Up to that time great difficulty had been experienced in procuring the different Oriental books required by the students in their studies; those that were obtainable were only to be had at great cost, while the type used was so bad and the paper of such indifferent quality that the books were oftentimes almost illegible. It was somewhat of a revolution, therefore, when "The Hitopadesa" was printed with new Sanskrit type at Hertford in 1847, as at that date there were not more than one or two Oriental printers in England, and thenceforward during successive years a great number of books printed in Sanskrit, Bengálí, Arabic, Persian, Pushto, Hindustání, Hindí, Hebrew, and other Eastern languages, as well as in Greek, Latin, and French, were issued from the Hertford Press of Stephen Austin, which in due time acquired a world-wide reputation for Oriental printing, and many of the finest specimens of Oriental typography now extant bear his name. The skill and taste displayed in these productions were acknowledged by the presentation to Mr. Austin of gold medals by her Majesty the Queen and the Empress of the French, by the award of medals of the first class at the International Exhibitions held in London and Paris, and by testimonials from many of the most eminent Oriental scholars of Europe and India; and in the year 1883 the Congrès International des Orientalistes presented their diploma to Mr. Austin for services rendered to Oriental literature.

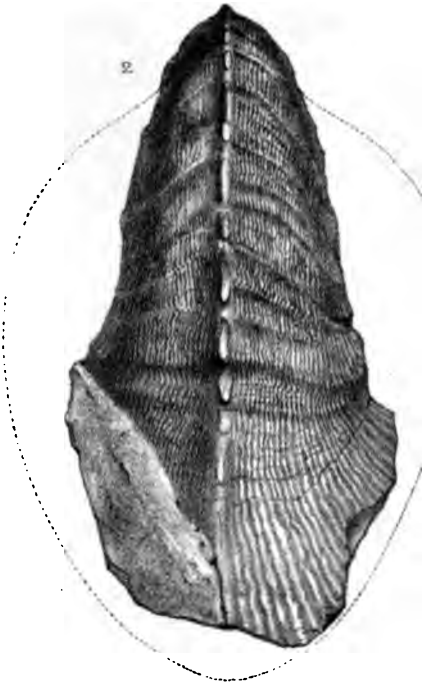
After the abolition of the East India Company's College at Haileybury, Mr. Austin was mainly instrumental in rescuing this historical place of learning from becoming an asylum or workhouse, and establishing the present successful Public School there; and in 1882 the Council of Haileybury College acknowledged Mr. Austin's valuable exertions by the presentation of a handsome service of plate.

In 1834 Mr. Austin established the "Reformer" Newspaper, now called the "Hertfordshire Mercury," which he has carried on successfully for more than fifty years.

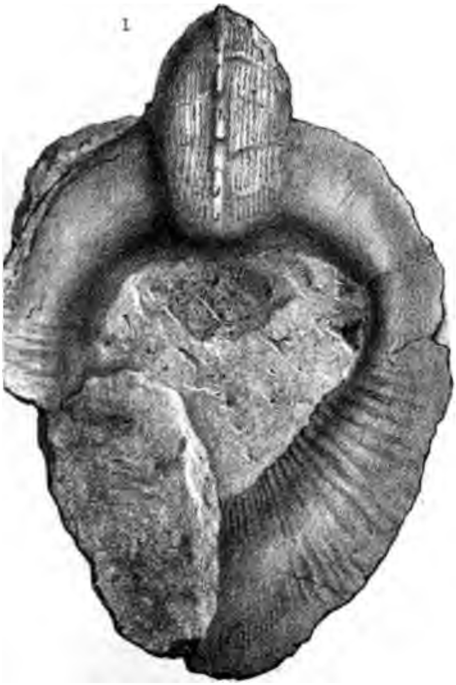
It would be impossible to speak here of all the public offices Mr. Austin held during his long life in connection with his native town and county, or of the many marks of esteem and regard which he received. He leaves five sons and four daughters to cherish his memory, and who will share with many associates a tender regret for the loss to them of an honoured parent, and to us, of a dear and valued friend. H. W.



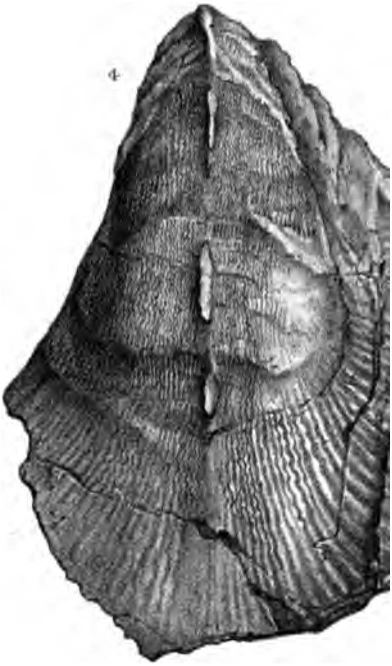
3



2



1



4

Berjeau & Highley del et lith

West, New

Trematonotus Britannicus nov.sp.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. IX.

No. VII.—AUGUST, 1892.

ORIGINAL ARTICLES.

I.—On the American Palæozoic Gasteropod, *Trematonotus* (Hall emend. P. Fischer), and its Identification in Britain; with Description of a New Species.

By R. Bullen Newton, F.G.S.;
of the British Museum (Natural History).

(PLATE IX.)

PROFESSOR JAMES HALL'S[1] discovery, in 1864, of his remarkable genus *Trematonotus*, in the Niagara rocks of North America, formed an interesting and valuable addition to his researches in conchological science.

The special features of this shell consist in its Bellerophontoid appearance, coupled with the presence of a single row of isolated perforations on the central part of the dorsal surface. It was somewhat erroneously regarded by its author as a sub-genus of *Leveillia*[2] (*Porcellia*),[3] though its unique characters would mark it as a distinct form, and probably more intimately related to the well-known *Haliotis* of our modern seas than to any other known shell.

Mr. F. B. Meek,[4] in 1866, considered the characters of Hall's genus as affording the evidence required to finally prove the Prosobranchiate affinities of the Bellerophontidæ, an opinion which the late Professor de Koninck[5] advanced as long ago as 1844 after a careful comparison of the genus *Emarginula* with the extinct *Bellerophon*. The views of the Belgian palæontologist on this point were very partially recognized, and only received adoption from Alcide d'Orbigny[6] in 1852, and Pictet[7] in 1855, since which dates they were classed with the Heteropods, until Meek's observations led to a reconsideration of the subject, and a general acknowledgement that the banded shells of the Prosobranchiate Mollusca must henceforth include the family of the Bellerophontidæ.

The type species of *Trematonotus*, and the only one then described, was *T. alpheus*, a name since ignored in favour of McChesney's

---

[1] Eighteenth Report Regents University, New York, 1864, p. 347; Twentieth ditto, 1867, pl. xv. figs. 23, 24.

[2] R. B. Newton, Geol. Mag. 1891, Pl. VI. p. 202.

[3] C. Léveillé, Mém. Soc. Géol. France, 1835, vol. 2, part 1, p. 39.

[4] Proc. Chicago Ac. Sci. 1866, vol. 1, p. 9.

[5] Desc. Animaux Foss. Carb. Belgique, 1844, pp. 334–338.

[6] Cours élèm. Paléontologie Géologie, 1852, vol. 2, p. 33.

[7] Traité Paléontologie, 1855, ed. 2, vol. 3, p. 287.

Bucania Chicagoensis[1] of an earlier date, and which is doubtless synonomous with it, as pointed out by S. A. Miller.[2] A second species was recorded by Messrs. Hall and Whitfield,[3] in 1875, as *T.* (?) *trigonostoma*, the authors placing a query against the genus because they were unable to distinguish the perforations in consequence of the obscurity of the dorsal region of their specimen. Both these species were obtained from the Niagara formation of Illinois and Ohio in the United States.

Another Palæozoic shell exhibiting a single row of openings on its whorls is d'Orbigny's *Polytremaria*,[4] founded on De Koninck's type of *Pleurotomaria catenata*[5] from the Carboniferous Limestone of Belgium. This form is sufficiently distinct not to be confounded with *Trematonotus*, being a small trochiform shell possessing a wavy band round its volutions, resulting in a series of what may be termed pseudo-perforations. De Koninck,[6] following d'Orbigny,[7] relegated it to the Haliotidæ.

The genus *Salpingostoma*[8] of F. Roemer, is also a shell with Bellerophontoid characters but having a wide umbilicus and bearing on its dorsal region a single elongate slit considerably removed from the apertural margin. Its type is the *Bellerophon megalastoma*[9] of Eichwald from the Silurian rocks of Russia. Dr. Paul Fischer makes reference to another perforate shell under the name of *Gyrotrema*,[10] but this is ascertained to be merely a manuscript genus of Barrande's which has been used for list purposes by Dr. J. J. Bigsby[11] and consequently of no zoological value until it is described and figured.

The Silurian genus *Tubina*[12] from Bohemia has three rows of tubular spines on its dorsal region, which, however, are rarely preserved, as they become detached and then have all the appearance of true perforations. One specimen of this genus in the British Museum exhibits the spines *in situ* and is the same species as that figured in Sir Richard Owen's "Palæontology" under the name of *Taubia armata*, Barrande (MS.) This genus is placed by Dr. Fischer in the Delphinulidæ.

The character of the orifices in *Trematonotus* was considered of sufficient importance by Mr. Ralph Tate[13] to claim the genus as a member

---

[1] Trans. Chicago Ac. Sci. 1859, vol. 1, pl. viii. figs. 4, 5, p. 69.

[2] North American Geology and Palæontology, 1889, p. 428.

[3] Rep. Geol. Surv. Ohio, 1875, vol. 2, part 2, pl. 8, fig. 5, p. 146.

[4] Prodrome Paléontologie, 1849, vol. 1, p. 122.

[5] Desc. Anim. Foss. Carb. Belgique, 1844, pl. xxxii. fig. 1, p. 374.

[6] Faun. Calc. Carbonif. Belgique, Ann. Mus. R. Hist. Nat. Belgique, 1883, vol. 8, part 4, p. 10.

[7] Cours élèm. Paléontologie, 1852, vol. 2, p. 21.

[8] Lethœa geognostica (Palæozoica) 1876, pl. v. fig. 12.

[9] Silurische Schicht. Esthland, 1840, p. 111.

[10] Manuel Conchyl. 1885, p. 854.

[11] Thesaurus Siluricus, 1868, p. 167.

[12] A manuscript name of Barrande's. Genus first figured and described by S. P. Woodward, in Sir Richard Owen's "Palæontology." 1860, pp. 71 (fig. 17, No. 8), 78; a fuller description afterwards appearing by Dr. Paul Fischer in his "Manuel Conchyliologie," 1885, woodcut, fig. 587; pp. 830, 831.

[13] Appendix, S. P. Woodward's Manual of Mollusca, 1868, p. 39.

Haliotidæ, and by this classification he at once added a far
antiquity to the family than had hitherto been accorded it.
ition for the genus would appear to be the most natural one
ld be suggested, since we may fairly assume that the open-
the dorsal surface would, during the life of the mollusc, be
r the ejectment of fœcal matters and for supplying the
e with water, as is known to be the case in the existing
. Some interesting observations on this feature of the
genus were published a few years ago by Mr. Edgar A.
when recording a species of *Haliotis* exhibiting the abnorm-
two rows of perforations. In his remarks he gives the
of the anal and branchial regions as immediately beneath
ces.

the publication of the second species of *Trematonotus*, in
othing further respecting its history has appeared; and it
d that a notice of its occurrence elsewhere may prove a
of considerable interest to the palæontologist.

new material suggesting this communication consists of two
rked shells, which appear to be referable to this genus, and
g homotaxially to the same horizon as the American species,
been obtained from the Wenlock Beds, in the neighbourhood
ey. They originally formed part of the celebrated "Johnson
n," now in the possession of the Geological Department of
ish Museum.

ssor Hall's rendering of the generic name was *Tremanotus*;
ugh an inaccurate compilation of that word Dr. Paul Fischer
le it the occasion of an alteration, and it now appears as
notus.[2] The original diagnosis stands as follows:—"Volutions
tly in the same plane; umbilicus on both sides; aperture ex-
; the dorsal line pierced by several oblong perforations."

TREMATONOTUS BRITANNICUS, n.sp.

fic characters.—Shell symmetrical, discoidal, cordiform, with
tions; umbilicus obscure; dorsal surface narrow near spiral
then suddenly expanding, convex, thinning out towards
with a gradual reflection; central ridge composed of slightly
longate perforations which cease after extending to about
ths the length of the shell; ornamented with rather closely-
y striæ, running parallel to the central ridge, which are
outwards as they reach the expansion, and marked trans-
with several arched lines of growth. The ventral surface
much expanded aperture, wedged in which is the elliptically-
horl containing the inner volutions; this whorl bears traces
erforations which are probably more or less filled up; the
mber is cordiform and deep and is bordered by a wide and
g lip which is thin, slightly convex, and ornamented with
radiating striæ; aperture entire.

sions.—Height = 90 mm.; width (maximum) = 65 mm.;

---

[1] Annals, 1888, pp. 419–421.

[2] Manuel Conchyl. 1885, p. 854.

length of ventral aspect of volution = 35 mm.; width of ventral aspect of volution = 18 mm.; width of the lip = 15 mm.

Observations.—The most perfect of the two specimens shows both surfaces but dorsally the expansion is obliterated by matrix. The perforations, though perhaps not quite so regularly placed as observed in Hall's drawing of the type species, are nevertheless prominent and unmistakeable. They are somewhat obscure on the ventral face of the whorl, where probably they are more or less filled up; but slight risings and depressions in the central ridge seem to indicate their presence. Viewed dorsally this character is more striking. Here the holes are narrow and elongate, the central one being longest; they are raised and quite distinct, with a depression between each. After extending to within about three-fifths the length of the shell the perforations cease and the central ridge becomes more or less merged in the longitudinal striæ which ornament the fossil. Adherent to the surfaces of this specimen are some imbedded examples of *Spirorbis Lewisi* (*tenuis*),[1] and some Polyzoon growths. The second specimen is a cast of the dorsal surface only, in which the siphonal openings are present but fewer, thus forming a distinction which might be a reasonable excuse for treating it as a separate species but in the absence of additional material it is perhaps safest to regard it as the same. The expansion is absent but the radiating striæ observed near the spiral region are sufficient to indicate its existence when the shell was more perfect. The margins in both specimens are quite entire, there being no evidence of an apertural sinus. The umbilical areas have suffered through pressure and are consequently obscured, so that their exact limits cannot be accurately appreciated.

This new species bears a resemblance to *Bellerophon dilatatus*[2] of J. de C. Sowerby, from the Ludlow rocks of Burrington; but that shell is more largely umbilicated and its central ridge is non-perforate. An unfortunate mistake regarding this species was made by Mr. S. P. Woodward, who figured on plate xiv. fig. 28 of his celebrated "Manual of the Mollusca" the *B. dilatatus* and named it *Bellerophon expansus*, a shell which has a deeply sinuate margin and is altogether quite distinct from the more robust form of the other species which has its margin entire.

This error has been copied by Dr. Paul Fischer, who, using the same plates for his "Manuel" as illustrated Woodward's earlier work, suggests a relationship between *B. expansus* and *Trematonotus*, the *B. dilatatus* being clearly the form meant in his reference. After an examination of several specimens of this species, both at the Geological Museum, Jermyn Street, and at the British Museum, no trace of perforations could be discovered. The Wenlock specimens differ also from the type *T. Chicagoensis*, which has a wide umbilicus exposing all the spiral system, though in the elongate character of its dorsal orifices it appears to be remarkably similar.

An analogy, at first sight, seems to exist between the British ecies and *T.* (?) *trigonostoma*, if we may judge from Hall and hitfield's figure, which exhibits the discoid spiral region wedged between the apertural lips, in other respects the American ecies differs in being deeply sinuate, and possessing no perforations.

---

[1] Murchison's Silurian System, 1839, pl. 8, fig. 1, pp. 616, 617.

[2] Murchison's Silurian System, 1839, pl. xii. figs. 23, 24, p. 627.

In making an examination of the Silurian Gastropods in the rmyn Street Museum, through the kindness of my former col-igue, Mr. George Sharman, the Palæontologist, my attention was rected to three specimens, on a tablet numbered $\frac{2}{7}\frac{4}{8}$, from the ›wer Ludlow of Mary Knoll, all of which were referred to *dilatatus*, though probably only one of them could with safety referred to that species. One of these three specimens had a wide nbilical region, as well as some raised prominences on the central rt of its dorsal surface, strongly suggestive of perforations, and other respects the specimen appeared to closely resemble the nus *Trematonotus.*

EXPLANATION OF PLATE IX.

G. 1. *Trematonotus Britannicus*, R. B. Newton. Ventral view.
e. 2. Dorsal view of same specimen; the dotted outline indicates the extent of expansion which is hidden by matrix.
G. 3. Profile of same exhibiting the reflected lip and the raised perforations.
G. 4. Dorsal view of another specimen with fewer orifices.

The figures are drawn of the natural size.

.—ON CERTAIN AFFINITIES BETWEEN THE DEVONIAN ROCKS OF SOUTH DEVON AND THE METAMORPHIC SCHISTS.

(Part III.)

By A. R. HUNT, M.A.

(*Concluded from page* 294.)

THE INTENSITY OF THE METAMORPHIC ACTION.

N the Devonian sandstones and grits of Torbay abundant quartz veins are occasionally developed, indicating a moderate amount heat. Neither the quartz-grains nor occasional fragments of felspar e to any extent affected.

At Dartmouth, on the raised-beach platform, quartz is largely eveloped together with a little felspar and chlorite, indicating ifficient heat to form or re-form these minerals. At Slapton Sands ie grits are about the same as in Torbay: felspar granules remain igular and intact.

Between Beesands village and Tinsey Head the quartz-grains ccasionally show signs of incipient solution, as also do the tour-alines. In one slide (No. 5) the approach of schistosity seems to heralded by minute roughly parallel cracks cemented by iron es and a pale-green mica.[1] Minute crystals of pyrites, some ctangular, are formed in the rock. At the Start, in rare cases, rains or remnants of grains of original granitic quartz can be etected in the schist.[2] Tourmaline is partially dissolved with re-ystallization.[3] In the Bolt district no trace of original minerals as been detected even in the least altered of the schists. In the iabases the amount of alteration is irregular. Near Dartmouth we meet with both ordinary fine-grained diabases, and diabases which have almost lost their original minerals by chemical processes. At Winslade quarry, in the same block, we note an ordinary diabase, and a chloritic rock whose augites are almost past detection. Near the Start we find a metamorphosed volcanic rock, apparently a plagioclase-pyroxene variety, which may well have been first altered by chemical action, and subsequently sheared and metamorphosed dynamically, with development of fibrous hornblende and zoisite.[1]

---

[1] Plate 7, fig. 2.
[2] Plate 7, fig. 1.
[3] Plate 6, fig. 2.

The evidence of the above rocks, from Torbay, and more especially from Dartmouth, westward, seems to indicate that the passage is from rocks affected by a high temperature and pressure, to rocks affected by a higher temperature and pressure, the one below and the other above the heat requisite for the ready solution of the quartzose, schorlaceous and felspathic components of the rocks involved; hydrothermal conditions being prevalent in each case.

THE CHARACTER OF THE METAMORPHOSIS.

Hydrothermal action would probably suffice to account for the passage of the micaceous sandstones into quartzites, and with pressure added, into quartz-schists; but simple hydrothermal action will not meet the case of the altered diabases. Even so far east as Dartmouth we find an uncrushed diabase at Sandquay with its original augite crystals nearly obliterated, and we know from the experiments of M. Daubree that augite is not affected by plain superheated water.[2]

The augite crystals of the South Devon diabases are often pierced by laths of felspars: felspar in decomposing would tend to produce silicate of aluminium—clay. According to Miller, "the intermixture of lime magnesia and oxide of iron with clay . . . causes it to be more readily attacked by acids."[3] In a decomposing crystal of augite pierced by felspar, we have the exact conditions for accelerating the action of acids, viz. the association of lime, magnesia, and iron with clay. In ordinary cases water, charged with carbonic acid by decomposing vegetation, percolating through the diabase, might in the presence of heat go far towards the production of secondary felspar, chlorite, and hornblende; but the complete metamorphosis undergone by the green schists seems to call for more active agents in the form of strongly acidulated mineral waters.

In the green schists of Bickerton and Rickham Sands, we have granules of felspar,[4] probably albite, embedded in a matrix consisting chiefly of chlorite. and in the former occasional epidote and carbonates.

In the diabases we have crystals of augite in a matrix of felspar, probably a lime-soda felspar. In the Southern rock we have a magnesian matrix, and in the Northern a non-magnesian matrix. For the passage of the Northern rock into the Southern, as repreed at Bickerton, a large accession of magnesia is requisite; and he carbonates a considerable amount of carbonic acid.

---

[1] Appendix, slide 40.

[2] Géologie Experimentalo, vol. i. p. 207.

[3] Elements of Chemistry, vol. ii. (third edition), p. 509.

[4] In these rocks there is often a marked alineation of the felspar.

ydro-thermal and dynamic action combined seem to meet the provided that the super-heated water be sea-water charged with onic acid. An instance of hot salt water, probably sea-water, g rise to chlorite, brown hornblende, pale-green actinolite, and tes is recorded by the late Mr. J. A. Phillips in the case of the l Seton Mine.[1] Mr. Ussher has sent me a specimen of an acid tive rock, occurring within a mile and a half of the metamorphic whose quartzes are charged with fluid carbonic acid; so we evidence of volcanic action, with abundance of carbonic acid, e neighbourhood of the green rocks.

ith magnesia and carbonic acid available from an outside source rocess of metamorphism seems easy.

arting with augite and lime-soda felspar, we have (leaving out which is common to all the original minerals concerned; and which is common to all except felspar) :—

$$\frac{\text{Magnesia, lime}}{\text{augite}} + \text{Alumina} = \frac{\text{Alumina, magnesia, lime}}{\text{hornblende.}}$$

$$\frac{\text{ina, magnesia, lime}}{\text{hornblende}} + \text{Carbonic acid} = \frac{\text{Alumina, magnesia}}{\text{chlorite}} + \frac{\text{Carbonic acid, lime}}{\text{calcite.}}$$

n,

$$\frac{\text{mina, lime-soda}}{\text{felspar}} + \text{Carbonic acid} = \frac{\text{Alumina, soda}}{\text{albite}} + \frac{\text{Carbonic acid, lime}}{\text{calcite.}}$$

$$\frac{\text{Alumina, lime-soda}}{\text{felspar}} + \text{Carbonic acid} + \text{magnesia} =$$

$$\frac{\text{Alumina, lime, magnesia}}{\text{hornblende}} + \text{Albite} + \frac{\text{Alumina, magnesia}}{\text{chlorite}} + \text{Calcite.}$$

us carbonated sea-water acting on augite associated with a lime- felspar, supplies all the materials for the formation of the dary materials, hornblende, chlorite, felspar and calcite, which the mass of the Green Rocks.

e epidote of the Green Rocks seems to be often associated with ter-clear felspar, entirely free from decomposition and possibly . The decomposition of a lime-soda felspar such as labradorite d account for the association of albite with epidote, *e.g.*

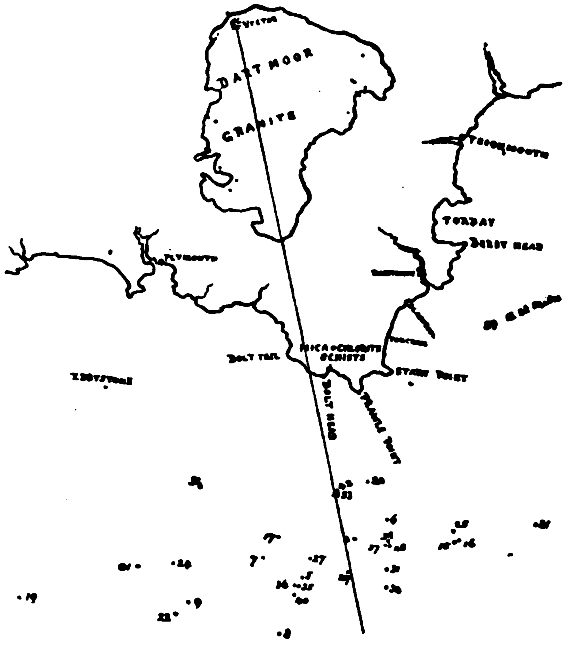
$$\frac{\text{Alumina-lime-soda}}{\text{Labradorite.}} = \frac{\text{Alumina-soda}}{\text{albite.}} + \frac{\text{Alumina-lime.}}{\text{epidote.}}$$

ere seems weighty evidence in support of the hypothesis that etamorphic rocks of S. Devon are Devonian, and of about the age as the sandstones and slates with *Pleurodictyum problema-* of the northern shore of Torbay; in which case the genesis ese Devonian schists should prove an attractive problem for ists and petrologists. Should the schists however ultimately to have no connection with the Devonian rocks, the two her will surely afford an unparalleled example of undesigned idences.

---

[1] Phil. Mag. ser. 4, vol. xlvi. pp. 30, 31.

The annexed sketch chart of the positions of the crystalline trawled-blocks, prepared long since to compare the relations of these rocks with the granite of Dartmoor, brings out the curious fact that a line drawn from the highest land in Dartmoor into the English Channel, dividing the blocks equally, passes through the centre of the Bolt district. It also passes within about half a mile of Stolliford, North Bolbury, and South Down Farm, whence I have received respectively the most schist-like Devonian diabase, the most hornblendic of the granular Green Rocks, and the most altered of the quartz-schists, in my collection of slides.



Map showing relative positions of the Dartmoor Granite, the South Devon Schists, and blocks of Crystalline Rocks trawled in the English Channel.

It only remains for me to render my best thanks to those friends who with entire disinterestedness have assisted me from time to time by instruction and otherwise, in investigating the affinities between the altered and unaltered rocks of South Devon. Without the kindly and varied help of Messrs. Harker and Teall and of the late Mr. Tawney with the rock sections, and that of Messrs. Ussher and Somervail with the rocks themselves, the present paper could scarcely have been written. For all conclusions, and errors, I assume entire responsibility, whilst crediting my aforesaid friends with being directly or indirectly the originators of whatever may be of value in the foregoing pages.

PARALLELISMS BETWEEN THE DEVONIAN AND METAMORPHIC ROCKS.

DEVONIANS.	METAMORPHIC ROCKS.
Micaceous sandstones }	*Micaceous quartz-schists* }
Micaceous slates }	*Mica-schists* }
Diabases }	*Green Rocks* }
Slates }	*Mica-schists* }
Micaceous grit-bands in slates	*Micaceous quartz-schist bands in mica-schist*
In *grit-bands*	In *quartz-schists*
Quartz-grains with negative crystals	Quartz-grains with negative crystals
Quartz-grains with hair-like inclusions	Quartz-grains with hair-like inclusions
Detrital tourmaline	Detrital tourmaline
Re-crystallized secondary tourmaline	Re-crystallized secondary tourmaline
White mica	White mica
Ferruginous laminæ with filmy mica	Streaks of iron with filmy mica
Pyrites crystallized in cubes and prisms	Pyrites crystallized in cubes and prisms[1]
Hæmatite cementing cracks.	Hæmatite cementing cracks
Black granules, magnetite (?)	Black granules, magnetite (?)
Diabase }	*Compact Green Rocks* }
Schistose diabase }	*Green schists* }
In *Diabase*	In *Green Rocks*
Secondary quartz	Secondary quartz
Compact hornblende	Compact hornblende
Fibrous hornblende	Fibrous hornblende
Felspar	Felspar
Epidote	Epidote
Two chlorites	Two chlorites
Iron ores	Iron ores
Veins in slates	*Veins in mica-schists.*
Felspar	Felspar
Quartz	Quartz
Chlorite	Chlorite

Calcite is abundant both in the Devonian and metamorphic rocks. No comparison has been attempted owing to the uncertainty of its origin.

In the spring of last year Mr. Harker was kind enough to examine eight specimens of the altered and unaltered rocks of South Devon, lettered in three series, as they seemed to me to invite comparison.

The following valuable notes were received by me on the 20th May, 1891, accompanied by permission to make any use of them. Although a far more complete set of rocks could now be selected for comparison, the following have the unique advantage of having been described at the outset of the investigation by a specialist, who, besides having no detailed information about the mode of occurrence of the specimens themselves, was not especially interested in the problem of the schists of South Devon.

---

[1] In siliceous band south of Hope Headland.

APPENDIX.

NOTES BY ALFRED HARKER, Esq., M.A.,

Fellow of St. John's College, Cambridge.

(26) A_1. *Sandquay Quarry.*

This is a much altered diabase, the original augite and felspar being almost totally destroyed. Here and there traces of a characteristic ophitic structure can be discerned; but there has also been a porphyritic development of larger crystals of felspar, and to a less extent of augite, as indeed is seen in the hand-specimen. Rare needles of apatite and grains of iron-ore are to be reckoned among the original constituents.

The most interesting feature is seen in the numerous little veins which traverse the slide, clearly representing cracks filled by secondary minerals. The clear material of these little veins seems to be in some places quartz, but most of it is felspar with evident twin-lamellation. This mineral has generally grown perpendicular to the walls of each vein, but where the cracks traverse porphyritic crystals of felspar, the new felspar substance is oriented in the same way as the old, with its twin-lamellæ parallel to the almost obliterated twinning of the original crystals. A considerable amount of pale fibrous amphibole is enclosed by the felspar and quartz of the veins, the fibres set perpendicularly to the walls of the vein in each case. Another mineral enclosed is a chloritic substance in vermicular growths.

The appearances in this rock do not demand any agency beyond those involved in the ordinary processes of 'weathering.' The secondary growth of felspar is now well known in rocks in which there is no reason to suspect any 'metamorphism' as ordinarily understood.

(31) A_2. *Combe Cross Quarry, Higher Fuge, West of Stoke Fleming.*

This rock is a diabase less decomposed than that of Sandquay. A considerable amount of fresh light-brown augite remains, and is seen to be penetrated by the lath-shaped sections of decomposed felspar in the ophitic fashion so characteristic of diabasic rocks. There is no porphyritic structure in this specimen. Iron-ores are rather abundant, and in reflected light the black ground is seen to be crossed by white or grey bars in the manner which has been supposed to indicate a parallel intergrowth of magnetite and ilmenite. As before, there are veinlets consisting of clear lamellated secondary felspar, and a rather fibrous amphibole. The latter is here better developed than in the preceding slide, and has a pale-greenish to brownish tint. Both minerals have grown perpendicularly to the walls of the little cracks. The pale secondary amphibole is also seen in places forming a narrow fringe to the augite plates, and showing the usual crystallographic orientation with respect to that mineral. This is a phenomenon met with in some districts which have been subjected to more or less mechanical stress,[1] but it cannot be urged as a *proof* of dynamic metamorphism.

(33) A_3. *Mill Hill Copse Quarry, Blackpool Valley.*

This is a schistose rock, precisely such as would result from the crushing of the diabase A_2. The schistosity, well seen in the hand-specimen, is marked in the slice by a general parallel arrangement of the constituents, and especially of those of secondary origin. The most abundant of these are a greenish-yellow mineral of the chlorite family and a pale amphibole. The latter has no longer the fibrous structure, but is compact, with evident hornblende-cleavage. Its absorption colours are pale bluish-green parallel to the γ-axis, and pale-brown perpendicular to that direction. The original ophitic structure of the diabase is preserved in certain little patches like 'eyes,' in which light-brown augite is seen, penetrated in the usual fashion by elongated crystals of felspar, mostly decomposed. A few felspars are still clear enough to show the twin-lamellation, and there are also relics of the original iron-ores, which are shown by the development of semi-opaque leucoxene to have been partly titaniferous. The augite, and to some extent the iron-ores, are traversed by fissures roughly perpendicular to the schistosity of the rock, a result of 'stretching' in the direction of the schistose structure. Most of the chloritic mineral in the rock polarizes in fairly high tints, but a portion of it gives only low interference-colours. When this mineral occurs in association with the pale hornblende, it wraps round the latter in a streaky manner. A little quartz-vein which traversed the rock, has been contorted and broken in the process of crushing, and affords some measure of the amount of compression in the direction perpendicular to the schistosity.

---

[1] *e.g.* Eastern Caernarvonshire: cf. Harker; Bala Volcanic Series of Caernarvonshire, pp. 83, 117; 1889.

(40) A_4. *Coast south of site of Start Signal House.*

This is a thoroughly metamorphosed rock. In its original state it has presumably been a diabase or some allied augitic type; but it is now converted into a mass of minerals newly crystallized *in situ*, and having the fresh appearance so characteristic of the crystalline schists. Original structures are completely obliterated.

There is abundance of the pale-greenish amphibole noticed above, partly in fibrous streaks and patches, partly in compact crystals, though usually with little indication of crystal-outlines. In a few places we notice crystals, bounded by the prism-faces alone, with no pinacoid, and with irregular terminations; but this is only when the amphibole is moulded by a certain pale scaly mineral, apparently one of the ripidolite group. The fibrous amphibole builds densely matted patches or occurs in isolated wisps enclosed in the felspar areas, and having a general parallelism with the rude schistosity of the rock as a whole.

Felspar occurs abundantly in aggregates of interlocking pellucid crystal-grains, rarely showing much indication of external crystal form. Twin-lamellation is very prevalent, and sections perpendicular to the lamellæ give extinction angles up to about 14°: this is not sufficient to distinguish between varieties of albite and andesine.

After the felspar and amphibole the most abundant constituents are epidote and zoisite. These form rather short columnar crystals, conspicuous, by their high refractive index, with indications of a longitudinal cleavage and a marked cross-jointing. The crystals give sensibly straight extinction. The two minerals are distinguished by the brilliant polarization of the epidote as contrasted with the low tints given by the zoisite. They occur in association with one another, and are moulded or enclosed by the other constituents of the rock. So far as our knowledge goes, epidote and zoisite are minerals characteristic of dynamic rather than thermal metamorphism in basic igneous rocks. The amphibole and felspar might well be formed in either case, but the rather coarse-grained aggregates of twinned felspars in this rock would, I believe, be difficult to match among products of "contact"-metamorphism.

(3) B_1. *Cliffs at North-east end of Slapton Sands.*

This is a reddish-brown, fine-grained, micaceous sandstone. As usual, the slice shows the little scales of colourless mica to be much less abundant than might be conjectured from the hand-specimen. They show an arrangement parallel to the bedding and are doubtless of detrital origin. The grains building the bulk of the rock are almost exclusively of quartz, in which both glass- and fluid-pores are detected. There is a ferruginous matrix separating the grains, and in places in sufficient quantity to show a well-marked lamination. An indication of "spectral polarization" in the quartz perhaps points to a certain degree of strain.

(4) C_1. *From the same Locality.*

This rock is very similar to the preceding, though with rather less of the ferruginous paste. An occasional grain of fresh lamellated felspar occurs among the quartz. The little mica-flakes are rare, but there are occasional rolled granules of tourmaline, both brown and blue. The quartz-grains enclose numerous fluid-pores, besides brownish inclusions apparently of glass, and an occasional little prism of zircon, etc. The rock has all the appearance of being derived from the destruction of a tourmaline-bearing granite.

(24) B_2. *North of site of Start Signal House.*[1]

This is a typical dynamo-metamorphic rock. The hand-specimen shows a schistose structure, accentuated by the development of a filmy secondary mica, and there are also rather acute zig-zag contortions. Under the microscope the structures characteristic of mechanical metamorphism show more decidedly. The clear granular patches of quartz, etc., have the well-known form of lenticular streaks, and smaller patches of similar character occur like 'eyes' imbedded in inconstant bands composed largely of colourless mica, the micaceous films showing the usual wavy parallel arrangement and clinging round the enclosed 'eyes.' In some broader bands, also rich in mica, both colourless and yellow or brown, the structures, developed by a shearing movement of the mass, are seen in various stages. First a system of minute unsymmetrical parallel folds is produced, their axial planes inclined at an angle of about 45° to the general schistosity of the rock. These folds become compressed and pushed over until they pass into little reversed faults about $\frac{1}{200}$ inch apart. The faults are formed at an angle of about 30° with the general direction of schistosity, but by further movement they come to coincide more closely with that direction, and are finally lost in the parallelism of the micaceous streaks.

---

[1] Plate 8, fig. 1.

The clear granular patches in the slide consist, at least for the most part, of quartz. The intricate interlocking of the several grains proves that the whole has crystallized *in situ*, and their imperfect extinction or 'spectral polarization' indicates a condition of internal strain. The rock may have been originally a shale or slate with some gritty bands. It compares very closely with the Skiddaw Slates, where they have undergone locally profound dynamic metamorphism, as at Brownber, in Westmoreland.[1]

(8) C_2. *South of Start Farm.*[2]

This is a type of rock which corresponds to what has sometimes been called a quartz-schist. The schistose character is but slightly marked in the hand-specimen. Minute scales of mica are arranged to give a parallel structure; but the mineral is only sparingly present.

Under the microscope the rock is seen to consist almost exclusively of clear grains of quartz of varying size and generally irregular shape. It is not clear that there has been any considerable recrystallization, and there is certainly nothing like the degree of metamorphism evidenced by specimen B_2. The few scattered flakes of colourless mica may be original. The slice is traversed by numerous little cracks cemented by opaque iron-ores. These are wavy and branching, but maintain a rough parallelism throughout the slice, agreeing in direction with the scales of mica.

III.—AN IRISH AUGITITE.

By BERNARD HOBSON, M.Sc., F.G.S.;
Assistant Lecturer in Geology at the Owens College, Manchester.

WHEN writing my paper "On the Igneous Rocks of the South of the Isle of Man,"[3] I was led to compare a Manx melaphyre, from Scarlet Point, with a rock described by Prof. E. Hull[4] as a melaphyre, occurring at Ballytrasna, near Limerick, and belonging to the "Upper Trap-band," a little below the basal shales of the Coal-measures. Through the kindness of Prof. Hull, a chip of the rock was sent to me by the Irish Geological Survey. The specimen was black and basaltic-looking. I did not obtain satisfactory sections of it in time for my paper, but have since had excellent ones made. On examining them I was immediately struck by the resemblance of the rock to the augitite of Paschkapole,[5] between Velmin and

---

[1] See paper by Prof. Nicholson and Mr. Marr, with Appendix; Quart. Journ. Geol. Soc. vol. xlvii. pp. 512-514 (1891).

[2] Plate 71, fig.

[3] Quart. Journ. Geol. Soc. vol. xlvii. (1891), pp. 432–450 (reprinted with additions in Yn Lioar Manninagh, 1892, pp. 337–348).

[4] "On the Microscopic Structure of the Limerick Carboniferous Trap Rocks," GEOL. MAG. 1873 (pp. 153–161), p. 157. Prof. Hull gives a list of papers relating to the geology of these rocks.

[5] Mentioned by H. Rosenbusch, Mikroskopische Physiographie der Massigen Gesteine (1887), p. 821.

Boreslau, in Bohemia, with a section of which I compared it. Professor Hull[1] describes the rock of Ballytrasna as containing "numerous large crystals and groups of banded felspar"; but I failed to find a single felspar in four sections, nor did I observe any in Allport's section, No. 1902,[2] from the same locality, which agrees with my sections. I submitted a section to Prof. H. Rosenbusch, of Heidelberg, from whose letter to me I translate: "Plagioclase I cannot find, it was most probably never present. In its early state the rock contained only augite and iron ores in two generations, a little biotite around the iron ores of the first generation, and probably a glassy base, which, however, I nowhere with certainty see preserved. On the contrary, it is changed to a chloritic substance, which is here and there speckled with brownish limonite." The structure of the rock is hypocrystalline porphyritic in Rosenbusch's[3] sense. The phenocrysts[4] consist of augite and magnetite, and perhaps biotite, if the inclusions of it seen in the augite phenocrysts are not due to crystallization of included ground-mass. The augite phenocrysts are idiomorphic and pinkish-brown in colour by transmitted light. Their maximum diameter is occasionally 2·9 mm., but more commonly 1·65 mm. or less. Twinning is rare. Zonal structure is common, so are magnetite and glass inclusions, the latter often altered to the chloritic substance before mentioned. The augite phenocrysts are themselves frequently partially or completely altered to a light-greenish serpentinous or chloritic alteration-product, and the pseudomorphs thus formed are often surrounded by interrupted patches of apparently secondary magnetite. Although the zonal structure defines the crystal faces with distinctness, yet the actual margins of the crystal sections are most frequently ragged or jagged and irregular, with magnetite crystals, or more rarely with augite crystals of the ground-mass, projecting into them. This irregularity of contour is well shown in fig. 19 (pl. xxxiv.) of Mr. S. Allport's paper.[5] I am inclined to regard it as due to the intratelluric augites continuing their growth during the period of effusion, rather than to a growth after consolidation of the rock.

The augite of the ground-mass occurs as very abundant idiomorphic crystals, mostly elongated in the direction of the vertical axis *c*. The average dimensions of the crystals are ·07 mm. × ·01 mm. They are faintly brownish in colour and are frequently twinned, the twinning plane being the orthopinacoid.

Magnetite is very abundant. It occurs as phenocrysts, often included in the porphyritic augites, as before mentioned, and is frequently idiomorphic, though in some cases the crystalline form cannot be made out with certainty. It is also abundant in the ground-mass. Not unfrequently it is partially altered to yellowish brown limonite.

---

[1] *Loc. cit.* p. 157.

[2] In the British Museum (Natural History).

[3] *Op. cit.* pp. 339–340.

[4] Term proposed by J. P. Iddings, "On the Crystallization of Igneous Rocks," Phil. Soc. Washington Bulletin, vol. xi. (1889), p. 73, for "porphyritic constituents" in Rosenbusch's sense.

[5] On the Microscopic Structure and Composition of British Carboniferous Dolerites, Quart. Journ. Geol. Soc. vol. xxx. (1874), pp. 529–567.

Biotite is present in only small quantity. Its pleochroism is, for rays vibrating parallel to the cleavage cracks, golden yellowish brown, for those at right angles to that direction faint yellowish brown. It not merely surrounds the magnetite of the first generation but appears to have crystallized after the augite crystals of the ground-mass, as the mica is allotriomorphic to them; in short they project into it as the felspars do into augite in ophitic structure.

The chloritic substance above mentioned by Rosenbusch, as probably replacing an original glassy base, is present in considerable quantity. It occupies more or less isolated angular spaces between, or surrounds all the crystalline constituents.

As the result of a somewhat hasty examination at the British Museum (Natural History) of Mr. Allport's section, No. 1900, of trap (from the Upper Trap band) of Rathjordan,[1] I found it to agree with that from Ballytrasna[2] in most respects, though I had not time to make certain whether phenocrysts of olivine were originally present, as both Allport and Hull[3] agree in stating. If so, it would be a limburgite. I take the "cells" mentioned by Prof. Hull, as occurring in the glassy base of the Ballytrasna rock, and the "tubes and cells" described and figured by him (pl. viii. fig. 9) from the Rathjordan rock to be really augite crystals of the ground-mass. That there is no improbability in limburgites (and augitites) being present among the Limerick traps is shown by a remark of Sir A. Geikie,[4] who states (apparently on the authority of Mr. W. W. Watts) that the upper basalts of Nicker Hill[5] contain "only 38·66 per cent. of silica" "thus approaching the limburgites."

As most of the traps from the Limerick district contain plagioclase there can be little doubt that the Ballytrasna rock is a basaltoid[6] augitite. It is probably more basic than the basalt of the Lion's Haunch, Arthur's Seat, Edinburgh, and than the Manx melaphyre with which I was led by Prof. Hull's description to compare it. So far as I know, the Ballytrasna augitite (I use the term regardless of geological age) is the first which has been described as occurring in the British Isles.

---

[1] Described by Allport, *loc. cit.* p. 552.

[2] Ballytrasna must be a very small place, as it is not marked on the One-inch Geol. Survey Map (sheet 154). I understand that it is about two miles east of Rathjordan.

[3] *Loc. cit.* p. 157.

[4] Anniversary Address to Geological Society, 1892; Proceedings p. 147 (p. 123 of separate copies).

[5] One-inch Geol. Survey Map, sheet 144 and Explanation, p. 31.

[6] H. Rosenbusch, Ueber die chemischen Beziehungen der Eruptivgesteine. Tschermak's Mineral. and Petrog. Mittheilungen, vol. xi. (1889) p. 158.

IV.—UNDERCLAYS: A PRELIMINARY STUDY.

By G. W. BULMAN, M.A., B.Sc.;
Corbridge-on-Tyne.

SINCE the advent, in 1840, of Sir Wm. Logan's paper "On the Characters of the Beds of Clay immediately below the Coal Seams of South Wales," underclays have generally been regarded as representing the soils on which grew the vegetation now forming the coal. I am not aware, however, that any definite and detailed hypothesis has been put forward to account for their origin. The superior interest attaching to the question of the origin of coal has apparently overshadowed the less important underclay, and it has been left to fit itself in with any particular hypothesis of the former which happened to be in favour. At the same time, two general views of its origin have been suggested which do not, however, go into any detail as to the exact manner in which it has been brought about. First, there is the opinion that underclays are terrestrial accumulations, thus expressed by the authors of the "Geology of the Yorkshire Coal-field":

"There can be no doubt then that the underclays are old vegetable soils, and that, unlike all the Carboniferous rocks we have hitherto noticed, they were formed not under water, but on dry land" (p. 19).

Prof. Hull, on the other hand, in his "Coal-fields of Britain," expresses the opinion that underclays were laid down in water:

"Now these underclays are distinctly stratified, showing that they have been deposited under water" (pp. 66-7).

Sir A. Geikie expresses a similar opinion in the following passage from his "Text Book of Geology," and further indicates that they were laid down in the *shallowing* water, just before it became a marsh and was taken possession of by vegetation:

"Where the clay was laid down under suitable circumstances, vegetation sprang up upon it. This appears to have taken place in wide shallow lagoon-like expansions of the sea, bordering land clothed with dense vegetation" (p. 477).

With regard to the first of these views it almost seems to be implied that the underclay was formed in the same way as a modern vegetable soil. But this interpretation may be dismissed at once, for the underclay, although it may well have played the rôle of foundation to the marsh, and received the roots of the vegetation, is not in the least like a vegetable soil, for a modern vegetable soil is formed of vegetable matter mingled with disintegrated rock, and passes by gradual transitions through the subsoil to the rock below. An underclay, on the other hand, is obviously an independent formation, and not formed by disintegration *in situ* of the rock below, from which it is separated by clear lines of demarcation.

The chief indictment against both these views of the origin of underclay is, that no example of the formation of clays at the present day, either on land or in very shallow water, has been brought forward. In fact, all we know about such fine grained deposits as clay leads us to attribute them—as a general rule, with a few exceptions—to quiet and deepish waters. Thus the formation of clay is described as follows in Phillip's "Manual of Geology":

"The carbonic acid, which is always dissolved in water, attacks the felspar by dissolving out from it carbonates of potash, soda, or lime; and then the crystals lose their hardness and become changed into a paste of impalpable fine particles which form a mud. This mud is held in suspension longer than the sand, and is therefore carried further out to sea. When it falls to the bottom and is compressed by the weight of the water above, it becomes clay, and margins or surrounds the land as an outer belt, probably twice as broad as the sand belt. On some coasts, like the South American coast mentioned by Mr. Darwin, there may be no clay deposited within one hundred and fifty miles of land" (vol. i. p. 50).

Sir Charles Lyell, again, describes the deposition of clay as taking place in the deeper portions of Lake Superior. And one of the results of the "Challenger" expedition has been to show that oceanic deposits in depths greater than 2000 fathoms are clays. But satisfactory cases of deposits at all analogous to underclays being laid down in a shallowing area just before vegetation commences to grow in the present order of things do not seem to be forthcoming. And if underclays were so deposited why are they not laminated?

That the geological study of clays is behind that of other rocks, while satisfactory evidence from causes now in operation is not forthcoming, seems to be indicated in the following quotation from Phillip's Manual (part i. ed. 1885):

"No such careful and detailed examination has been made of existing mud and clay as of sand or limestone. The subject is much more difficult . . . . and the observations on deposits now forming are too few to completely demonstrate the conditions under which many of the newer clay beds were formed."

In the following description by Prof. Green of the formation of coal there is no room left for the deposit of the underclay:

"But the downward movement was not without intermission; every now and then a pause occurred, and whenever this happened the water would tend to be filled up. Sand-banks formed shoals, which by degrees grew into islands: the channels between the islands were gradually choked up with sediment, till at last the whole or portions of the lake became replaced by swampy plains or morasses, across which sluggish rivers slowly wound their way. Vegetation spread from the adjoining land over the marshy flats, and under the moist and otherwise favourable conditions grew apace, till the whole became converted into a rank and tangled jungle" (Coal, its History and Uses, pp. 56–7).

According to this view the coal is evidently formed on a sand-bank.

The analogy of modern peat bogs, which are generally found to be underlaid by some sort of clay, is sometimes strongly insisted upon in connection with underclays; and yet, on examination, it appears that many of our peat bogs rest on clays belonging to a different geological age—as on the Boulder-clay, or on the clays of Coal-measures themselves—and so do not admit of comparison with the Coal-seam and its underclay. Those peat mosses, again, which form the most recent layer in the filling up of lakes do not require that the substratum should be universally an impervious clay; for the same causes which led to the formation of the lake in the first instance will prevent the drainage of the filled up area.

Sir Charles Lyell, indeed, in describing lake deposits in general, gives ***shell-marl*** as the stratum immediately below the peat, thus:

"If we drain a lake which has been fed by a small stream, we frequently find at the bottom a series of deposits, disposed with considerable regularity, one above the other; the uppermost, perhaps, may be a stratum of peat, next below a more dense and solid variety of the same material; still lower a bed of shell-marl, alternating with peat or sand, and then other beds of marl, divided by layers of clay" (Elements of Geology, p. 3).

And in the Meadows, Edinburgh, formerly the Borough Loch, the following section was met with in digging a drain, and is thus mentioned in the Survey Memoir of the Geology of the Neighbourhood of Edinburgh:

"A bed of lake-peat, from a few inches to upwards of a foot in thickness, was found immediately below the soil. A thin lay of marl, with the common freshwater shells, underlaid the peat and rested on silt, sand, or fine gravel, below which came the Boulder-clay."

In the Survey Memoir of the Geology of East Lothian two similar cases of peat immediately underlaid by marl are mentioned (pp. 67, 68).

According to Prof. Heer, again, the ground for the growth of peat as the final deposit in the silting up of a lake is due to Mollusca, and is thus described:

"The formation of an impermeable ground is the work of small mollusca, which live in the water in great abundance. After death their shells decompose, and gradually produce, with the inorganic deposits of the water, a sort of calcareous loam, called *blanc-fond* (white ground) in Neuchatel, and *lake-chalk* in the canton of Zug" (Heer's Primæval World of Switzerland, Heywood, vol. i. p. 24).

Clearly, then, the origin of underclays cannot be explained by the causes now in operation in the filling up of lakes.

As regards the occurrence of peat otherwise than as a lacustrine deposit, some interesting details are given in the Survey Memoir of the Geology of the South-west part of Lincolnshire. Several beds of peat at different levels and interstratified with clay, silt, sand, etc., occur. The following sections may be taken as examples:

		FEET.
(1).	Brown silty soil	1
	Reddish brown silt	1 to 4
	Blue clay	1
	Drab-coloured sandy clay	4 to 6
	Peat and peaty-clay	1
	Blue clay with marine shells	6
	Blue clay with peaty matter and wood at bottom	16
	Peat black and compact	1
	Coarse angular sand	1
	Bluish Boulder-clay, touched	1

(Brickyard one mile N.N.W. of Spalding. p. 107.)

		FEET
(2).	Brown silt	3
	Black peat	0½
	Sandy silt and loam with marine shells ...	5
	Yellowish clay	2
	Grey peaty clay	3
	Soft, clean, blue clay	2
	Peaty layer with drift wood and hazel nuts ...	0½
	Gravelly clay (? Boulder-clay) touched ...	
(Pit two furlongs East of Doveham. p. 108.)		
(3).	Peat	1
	Clay with Marine shells	6
	Silt, sandy	3
	Peat with trees	2½
	Gravel...	10 ?
(Tattershall Brickyard at Dogdyke near mouth of River Bain. p. 111.)		

The view advocated in the above memoir is that these deposits are the result of the silting up of a bay, and that they are marine deposits. The layers of peat occurring at various levels are held to be indications of old land surfaces. If this is so we must suppose there has been a filling up of the bay followed by a depression after its growth, for each bed of peat. Of such earth movements in the area under consideration there appears to be no independent proof, or we should have here a valuable illustration of the modern view of the origin of coal *in situ* with slow and intermittent subsidence. But some of the sections indicate rather a drift origin for some of the lower layers of peat. Thus in section (1) the peat rests on *coarse angular sand*, and in (3) on *gravel*, neither of which seems a likely substratum for a peat moss to flourish on. In (2), again, the layer of peat itself contains "drift wood" which is strongly suggestive of a *drift* origin for the peat itself.

The *clay beneath* the peat also frequently contains *marine shells*, which have apparently never been found in the underclays of the Carboniferous. On the whole, then, it does not seem that the beds commonly found beneath layers of peat throw much light on the origin of Carboniferous underclays. Yet the occurrence of such fine-grained deposits as these clays, as the final member of the series in the silting up of an area, and just before the growth of vegetation, is a valuable suggestion as to how an underclay might, under certain conditions, be formed in a shallowing area, and in immediate proximity to land.

The conditions in the Fen district are, however, somewhat peculiar, for the clays are *marine* deposits, and must have been brought by currents from considerable distances.

It has been asserted that *Stigmaria* are of universal occurrence in underclays. Thus Professor Green writes of them, "They always contain a peculiar vegetable fossil known as *Stigmaria*" (Physical Geology, p. 258).

And this—on the hypothesis that *Stigmaria* are the roots of the vegetation which forms the coal—is one of the strongest arguments that the underclays are old soils. But it is to be observed that while *Stigmaria* appear to be of almost—if not quite—universal occurrence in underclays, they are also often found in sandstones, ven when these are entirely distinct and separate from Coal-seams. Thus examples of sandstone with Stigmarian roots, and separated from Coal-seams by beds of underclay, occur in the following ections from the Survey Memoir of the Yorkshire Coal-field:

		FT.	IN.	
(1).	Coal	0	3	
	Underclay	1	1	
	Sandstone with Stigmaria rootlets	2	0	(p. 634.)
(2).	Coal	1	3	
	Underclay			
	Sandstone with Stigmaria rootlets.			

And examples of *Stigmaria* in limestone are not unknown. Thus hey are found abundantly in the well-known Burdie House limetone of the Lower Carboniferous of Scotland.

Supposing that in all three cases, in the underclay, in sandstone, and in limestone, the *Stigmaria* are *in sitû*, it is a little curious that a plant which habitually grew in a swamp caused by an impervious tratum of underclay should flourish equally well on a sandbank or n a calcareous mud. It may, however, be suggested in explanation hat the *Stigmaria* roots represent more than one type, and were not ll marsh plants. And to suppose that *Stigmaria* in sandstone are sually *in situ* is to increase the necessary number of old land urfaces preserved in the Carboniferous period, already a serious ifficulty, reckoning Coal-seams and underclays alone.

As regards the question of the position of *Stigmaria* in sitû, and heir connection with the stems of the Carboniferous trees, it is to be noted that the most striking examples that have been brought forward are not in underclay but in sandstone. Thus the well-known case quoted and figured by Prestwich (Geology, vol. ii. p. 109), is in a sandstone. Moreover, the figure gives, on the whole, rather the impression of drift than growth, *in sitû*. And in that remarkable fossil forest near Sheffield, described by Dr. Sorby (Q.J.G.S., August, 1875), the roots of the trees ramify through a soft shaly clay, while the stumps are enveloped in a bed of sandstone. In the South Joggins section, too, and in the Cape Breton Coalfield, the more striking examples of stems with Stigmarian roots are found in the shale above the Coal-seams.

The occurrence of erect tree-stumps in connection with Coal-seams is certainly suggestive that the underclays have played the part of soils. And yet the very fact of the publication of papers "On *an* erect tree in connection with a Coal-seam," etc., seems to mark the rarity of the occurrence. But *if* the underclay really *was* the soil upon which was formed the coal by the growth of the Carboniferous forest, afterwards lowered beneath the water and enveloped in shale or sandstone, should we not expect such erect tree-stumps to stand as thickly as the trees in a modern forest?

But although the occurrence of erect tree-stumps is rarer than might be expected, Sir Charles Lyell mentions a portion of the South Joggins section, containing nineteen Coal-seams in which he bserved *seventeen* trees at right angles to the planes of stratification.

Of these he remarks: "In *no* instance could I detect *any trunk intersecting* a layer of coal, however thin; and *most* of the trees terminated downwards in seams of coal" (Elements of Geology, p. 391).

Yet had the underclay been really the ancient soil we might reasonably expect to find the trees extending downwards to it.

This south Joggins section is described in more detail by Sir J. W. Dawson (Acadian Geology, chap. xl.). In glancing through the details of the beds there given it is observable that *the greater number* of erect trees are in the *roofs* of the Coal-seams. The *erect* position of such trees is generally supposed to indicate that they are in their original position of growth. M. Fayol, however, has pointed out that in the Coal-fields of Central France a certain number of stumps of trees occur at right angles to the planes of bedding, although a larger number are horizontal, or inclined at various angles; and yet he has, I think, conclusively shown that the coal of this district is of drift origin. Hence we must admit that the occurrence of a *few* erect trees is in itself no sufficient evidence that they are in the position of growth.

Dr. Croll has pointed out the almost entire absence of old land surfaces throughout the geological series except the coal and underclays of the Carboniferous. The familiar "Dirt bed" of the Isle of Portland is one of the few exceptions. We must also except the Coal seams of the Yorkshire Oolite of which Sir A. Ramsay has said that they "have not been formed of drift vegetation, for underneath each bed there occurs an *underclay*, or old soil, charged with the roots of those plants the decay of which on the spot formed the thin beds of coal" (Physical Geology of Great Britain, pp. 194–5).

And Sir J. W. Dawson writing of the strata of the Erian (= Devonian) system of America, states that they "include fossil soils of the nature of underclays, in which little else appears to have grown than a dense herbage of *Psilophyton*, along with plants of the genus *Arthrostigma*" (Geological History of Plants, p. 105).

If, then, we accept the belief that the underclays of the Carboniferous are old land surfaces we are forced to the conclusion that the physical conditions of that period have been unique—at least as far as regards Europe. Perhaps, however, this conclusion is inevitable in whatever light we regard the underclays.

Sir Wm. Logan considered it a universal rule in the South Wales Coal-field that a bed of coal reposed on an underclay, and the generalisation has been extended to all our Coal-fields. But there are exceptions, and coal is found at times resting on ordinary sandstone or shale. And underclays without any Coal-seams resting upon them are of common occurrence. Thus in the South Joggins section of 14,570 feet in thickness there are said to be 76 coal seams and 90 stigmarian underclays; so that at least 14 of these latter are without accompanying coal. Indeed, according to Sir J. W. Dawson's method of interpretation there are something like 238 old land surfaces in this remarkable section, and he notes that "the forest soils are much more frequently preserved than the forests

Geology, p. 186).

Interesting examples of the independent occurrence of coal and underclay are also met with in the Carboniferous rocks of Scotland, where in not a few cases they are separated by beds of sandstone. The following sections from the Survey Memoir of the Geology of Edinburgh (32 Scotland, 1861) may be taken as examples:

(1).	FT.	IN.
Coal	0	3
Sandstone	3	0
Fireclay	23	0
Coal	1	5
Fireclay	9	0
Argillaceous shale ...	15	0
Coal	0	6
Sandstone	4	0
Fireclay	10	0
	(p. 100.)	

(2).	FT.	IN.
Coal	2	0
Fireclay	4	0
Coal	2	0
Sandstone and shale	45	0
Fireclay	18	0
	(p. 106.)	

Underclays thus occurring without coal are accounted for by Sir Henry de la Beche as follows (Memoir, South Staffordshire Coal-field, p. 338):

"As will be readily understood, even all traces of a coal above a *Stigmaria* bed may be absent, either from the carbonaceous matter having been removed by the stream or current of water which deposited new matter, such as sand, above it, or from the conditions not having been so far advanced as to permit the *Stigmaria* bed or soil to be coated over with such carbonaceous matter."

But denudation by streams of Carboniferous vegetation can scarcely have been sufficiently uniform over large areas to account for the entire absence of coal over Stigmarian clays; such denudation would rather cut channels and hollows in the coal. It would, moreover, have left marks of denudation in the underlying clay.

And even in those cases in South Wales—mentioned in a note on the same page of the Memoir—where the carbonaceous matter has been "entirely removed, and even channels cut in the supporting *Stigmaria* beds," it is difficult to believe that the deposit of vegetable matter could disappear so entirely and leave no trace of its presence. Sir H. de la Beche speaks of the erosion having taken place when the coal was "unconsolidated"; but the carrying away of a dense mass of vegetation firmly rooted in clay would require currents of considerable force. Still there is no difficulty in understanding denudation cutting channels in the coal—like the "Horse" in the Forest of Dean—but denudation which will neatly slice off a layer of coal from its supporting underclay is another matter.

Other cases occur in which the same seam of coal rests partly on an underclay, and partly on sandstone. The following three examples are from the Memoir of the South Staffordshire Coal-field:

(1) "There is often above it a bed of fireclay or clunch a few feet in thickness, supporting the sulphur coal, but that is frequently absent, and the coal rests directly on the rock" [a sandstone, known as the New Mine Coal rock] (p. 195).

(2) "The upper measure is generally fire-clay or clunch, supporting the fireclay coal, and varying in thickness from 2 to 10 feet. This, however, is sometimes wanting, and the fire-clay coal rests directly on a 'strong rock' or hard sandstone" (p. 203).

(3) "The Bottom coal usually rests on a bed of fire-clay some feet in thickness. In many instances, however, this is wanting, and the coal rests on hard sandstone, the change from one material to the other being sometimes very abrupt" (p. 209).

And underclay is at times so associated with sandstone as to suggest for it a similar origin as to place and manner. For example, in the Survey Memoir of the Yorkshire Coal-field we have the following section:

	FT.	IN.
Coal	0	9
Underclay with bands of sandstone	3	4
Black shale	0	1
Underclay	1	8

On the other hand underclay may be *mixed* with sandstone, as in the case of a white sandstone 3 ft. 6 in. thick, met with in a boring at Seaton Carew (Durham), and separated from a coal-seam above by 4 in. of dark-blue shale (Notes on the Seaton Carew Boring. J. W. Bird. Nov. 8th, 1888).

And in whatever place and manner underclays were formed, vegetable matter—probably drift—must in some cases have had access. For fragmentary masses of coal—in the form of strings and veins—are at times found in it, as in the following section from the Survey Memoir of the Yorkshire Coal-field:

	FT.	IN.	
Coal	3	6	
Uunderclay and Coal-veins	0	8	
Sandy underclay	1	6	
Sandy shale	1	9	
Sandstone	2	0	
Underclay and Coal-veins	4	1	
Underclay	2	0	(p. 519).

It is difficult to draw any distinction as to mode of origin between such cases and those in which the coal appears to play the *rôle* of "partings" in a seam of underclay, as in the following section:

	FT.	IN.
Coal	0	6
Underclay	4	1
Coal	0	1½
Underclay	2	2
Coal	0	4
Underclay	1	5
Coal	0	3

(Survey Memoirs, Yorkshire Coal-field, p. 167).

From this we pass naturally to the case of a Coal-seam in which the underclay partings attain the same thickness as the intervening coal, as in the following section of a portion of the "Fire-clay" coal of the South Staffordshire Coal-field:

	FT.	IN.
Little coal	1	6
Fire-clay	1	6
Coal	0	7
Fire-clay	2	5
Coal	2	7

[illegible] Memoir, p. 202).

And from this to an ordinary Coal-seam with "partings" of underclay, as in the following section of the Beeston Bed Coal, s but a step:

	FT.	IN.
Coal	2	0
Underclay	0	3
Coal	1	3
Underclay	0	5
Coal	0	5
Underclay	1	6
Coal	0	6
Underclay	0	2
Coal	0	2
Underclay	0	7
Coal	0	2
Underclay	0	2
Coal	1	8½

(Survey Memoir. Yorkshire Coal-field, p. 192).

Are we to look upon each "parting" of underclay as a separate soil and the foundation of a distinct marsh? And if so, ought we not also to consider all ordinary "partings" of a shaly, slaty, or clayey nature? It is a little difficult to understand, granting the formation of the underclay, how a stratum of clay two or three inches thick, could support the large trees which formed the greater part of the Carboniferous forests; and the earth movements required in the case of the above seam, supposing the underclay to be formed in shallow water and the coal on land, would be as follows:

After the formation of the lower 1 ft. 8½ in. of coal, there must have been a sinking of the land to the extent of two inches beyond the thickness of the bed of vegetable matter. This must have been followed by a pause of sufficient length to allow of the accumulation of two inches of underclay in the shallow water and the growth upon it of sufficient vegetable matter to form two inches of coal. This must have been followed by a submergence of this coal to the depth of seven inches, and a pause long enough for the deposition of seven inches of underclay and the growth upon it of two inches of coal. And so on to the top of the section. It is questionable whether we are justified in calling in such a system of earth-movements.

Finally it must be observed that a fine-grained deposit such as underclay is what we should expect to find beneath the coal on some such hypothesis of its drift origin as that of Mr. Goodchild (GEOLOGICAL MAGAZINE, July, 1889). For in a gradually sinking area the zone of deposition of sandstone and shale would gradually give place to that of clay and vegetable matter. Again, the want of lamination, which is such a striking feature of underclays in general, would be a *probable consequence* of deposition in deep, quiet water, far from land, since the supply of fine sediment would remain so long suspended that its settling down would be likely to be uninterrupted and almost uniform.

There are two ways in which lamination may be produced:

(1) By flat plates of mica, which settle down more slowly than the sand and mud, but in the same zone of sedimentation, and

thus forming separate layers, cause the latter to split up when consolidated.

(2) By the *periodical supply* of sediment—as by floods occurring at intervals—so that one layer gets settled down and partially solidified before the arrival of the next supply.

Both causes of lamination are absent in the deep sea zone of deposition; the particles of mica are too small, and the supply of sediment too continuous.

And the nature of the beds immediately associated with underclays is at times suggestive of a deepish water origin. Thus we frequently find a sandstone succeeded in ascending order by a shale, next to which comes an underclay, upon which rests a bed of coal, as in the following examples from the Yorkshire Coal-field:

(1)		FT.	IN.
Haigh Moor Coal	Coal	2	3
	Dirt	0	0¼
	Coal	1	7
Underclay and ironstone nodules		9	0
Soft black shale		0	10
Shale and ironstone		5	0
Sandy shale and sandstone		4	0

(Survey Memoirs, p. 714.)

(2)	FT.	IN.
Coal	1	0
Underclay	0	7
Shale and ironstone nodules	3	0
Sandstone	1	3

(Survey Memoirs, p. 712.)

And a glance through the sections given in the above Memoir shows that such an order of succession is exceedingly common—it may, indeed, almost be said to be typical—while those above the coal show not infrequently an inverse order, as in a portion of the Seaton Carew boring given below:

	FT.	IN.
Grey sandstone	4	0
Dark-grey sandy shale	0	7
Coal	0	10
Dark-brown fire-clay	1	2
Dark-brown sandy shale	2	8
Dark-grey sandy shale	1	8
White sandstone	26	8

The obvious and usual interpretation of such a succession beneath the underclay would be a change from the shallow-water sandstone conditions, through the deeper zone of shale to still deeper where the fine-grained underclay was laid down. Above the coal, again, the natural interpretation would be shallowing water. And the following section from the Lower Carboniferous of East Lothian is instructive:

Limestone 10 feet.
Seam of coal, 10 inches, and *fire-clay* under.
Shale.
White limestone.

(Survey Memoirs, East Lothian, p. 54.)

The lower limestone contains marine fossils: *Productus* sp., *Athyris* [illegible], *Rhynchonella pleurodon*, *Lithostrotion junceum*, and *L. irregu-*

lare. And the upper, which rests immediately on the coal, contains: *Rhynchonella pleurodon*, var., *Fenestella plebeia*, *Encrinites*, etc. Here the interpretation of conditions would naturally be deepish water for the lower limestone, a change to shallower for the shale, and *after* the deposition of the underclay and coal a return to such deepish water for the upper limestone.

V.—ON THE OCCURRENCE OF A BLACK LIMESTONE IN THE STRATA OF THE MALTESE ISLANDS.

By JOHN H. COOKE, F.G.S., etc.

WHILE engaged in the examination of the superficial deposits of the Maltese Islands, I have often met with rounded pebbles and angular fragments of a black, crystalline limestone, either lying on the rock surfaces, or embedded in the Quaternary formations.

The late Professor Leith Adams drew attention to the same fact as long ago as 1867, and in a paper which was published in the Quart. Journ. Geol. Soc. he expressed an opinion that the fragments which he had seen lying on the surfaces of the sides and summits of the Gozitan Hills, belonged to a formation that was of a much later age than any of the rocks that are now to be found *in situ* in the islands.[1]

Dr. John Murray, too, notes in his *brochure*[2] on the Maltese Islands the occurrence of similar fragments in the neighbourhood of Marsa Scirocco, and he further adds that no evidences of the rock having been found *in situ* in the islands had hitherto been recorded. The remarks of these gentlemen led me to consider the matter attentively, and I have, during the last year, been carrying on investigations with the object of discovering the origin of the black marble, the result of which has been to show that it is but a variety of the Lower Coralline Limestone, the basement bed of the Maltese series, and that it occurs extensively *in situ* in that formation. In the eastern and south-eastern parts of Malta considerable quantities of rounded boulders and angular fragments of black limestone, that vary in size from a walnut to a medium-sized pumpkin occur in the beds of the gorges, in the soil of the fields, and in all those localities where the Globigerina limestone has been eroded away, and the underlying basement rock has been exposed to view.

In the Quaternary strata, too, of both Malta and Gozo these fragments are especially numerous. The elephant bed in the Benhisa Creek at the south-eastern extremity of Malta affords a characteristic example of their mode of occurrence in the diluvial beds of the island.

In this bed large water-worn boulders, having, when broken, a jet-black lustre, occur at different depths intermixed with boulders and fragments of other colours, eighty per cent. of which are at once recognizable as having been derived from the formation out of which the creek has been formed. They generally lie with their longer axes in a horizontal direction, forming well-defined layers of several feet in thickness, alternating with beds of a rich red soil, containing the remains of several extinct species of elephants.

---

[1] Dr. Adams says, "Indications of more recent beds are seen in the blocks of weathered limestone known as Gozo marble which are seen strewing the valley eastward of the lighthouse on the northern shore, and in fragments of a black limestone or marble which strew the sides and summits of the Gozo Hills. There can, I believe, be no doubt that these fragments have no connexion whatever with any of the recent formations in the islands."

[2] "The Maltese Islands, with special reference to their Geological Structure," Scottish Geol. Mag. September, 1890.

It was to this part of the island that I first directed my attention in my search for the origin of the bed from whence these boulders and pebbles had been derived, as, owing to the great amount of denudation to which the country around had been subjected, the whole of the beds, that had formerly overlain the basement rock, had been completely swept away, and the Lower Coralline Limestone had been laid bare over an area of several square miles in extent. The first evidence of the black limestone occurring *in situ* appeared on the road between Benhisa and Uied el Mista. The exact spot is situated directly opposite to Il Mara, at a distance of about 400 yards from the sea cliffs. It consists of a patch of black crystalline marble, which is similar in every respect to the limestone of which the boulders and pebbles are composed. The patch extends half-way across the road, and on the off side a cart-rut has been formed in it to a depth of eight inches. It occurs in division *b* of the Lower Coralline Limestone, but as no sections were in the vicinity it was not possible to determine its thickness. Judging, however, from a fragment which I detached at the bottom of the rut, and which showed a gradual transition of the black into the characteristic yellow variety of the formation, it is not probable that it is more than a foot. I broke off several pieces and made sections of them, as well as of several of the pebbles from the Benhisa Creek, which is not more than a mile away.

An examination under the microscope showed the specimens from both localities to have a granular texture, with here and there numerous well defined patches of calcite having a semi-radiated structure.

The insoluble residue that resulted after treatment with hydrochloric acid was chiefly composed of siliceous particles, and of flocculent, carbonaceous matter which remained in suspension in the solution for some considerable time. Both were hard, compact, and crystalline; and chemical analysis revealed the presence of sulphide of iron. The specimens were evidently identical. About one mile from this spot, and situated about 200 yards to the west of Ghar Hasan's Cave on the same coast, there is another patch or vein, which is similar in every respect to that to which reference has just been made. It occurs on the cliff edge, and at the western extremity of the first wall which is met with after leaving the cave. It is but small, having a diameter of four feet only, and as it does not abut on the cliff face its thickness was not shown.

Neither of the patches were of any great extent, and would not of themselves be sufficient to account for the quantities of blocks and fragments that lie scattered over the rock surfaces in their vicinity. It is probable that they are the remnants of the patches and veins that formerly occurred in those portions of the Lower Coralline Limestone that were broken up when the upper deposits of the district were swept away. As I shall afterwards show when describing the occurrence of similar veins in the Gozitan beds, this black crystalline variety of the basement rock is still very common in the upper layers of that formation. In the Malta district to which I have just been referring these upper layers have been completely swept away, and nearly all traces of black veins have thus been obliterated.

In Gozo its mode of occurrence may be studied to the best advantage in the Lower Limestone quarries that are situated on the southern coast in close proximity to the church of the Madonna della Kala, and immediately opposite the islet of Comino. Fragments of a red as well as of a black variety are strewn around the hillsides in great number, while quantities of red and of black chippings are to be found intermixed with the debris of the quarry.

The sections that the quarrymen have cut, show that both varieties occur in thin irregular veins of from one foot to three feet in thickness, and from ten to twelve feet in length; or as irregularly shaped patches having diameters ranging from three to eight feet. In some instances several smaller veins ramify from the main seam, and after pursuing an irregular course of a few feet in a horizontal direction, they break off abruptly.

It is in and around the "Scutella" seam which forms the capping of the Lower Limestone, that the greatest number of veins and patches seem to occur; they are, however, found in the underlying divisions also.

The different varieties of rock vary greatly in their lithological aspects in different parts of the bed. In the upper divisions they are of a coarse texture and granitic appearance, and their fossil contents consisting of *Orbitoides*, *Echini*, and *spines* are plainly discernable; but in the lower parts, their close fine grain causes them to exhibit an exceedingly homogeneous appearance. Another locality in which the red variety is extensively developed is the bottom of the valley which is situated midway between Ras-el-Hecca and Uied tal Assiri on the northern coast of Gozo. The torrent that tears its way down the bed for a few occasional hours during the rainy season has there laid bare the basement rock, and has exposed a large patch of bright, red limestone that answers in every particular to the rock of which the numerous fragments that lie scattered over the surrounding slopes, are composed.

In common with the other rock fragments with which the country is strewn, there can be no doubt but that these black and red varieties were derived from the island's formations at a time when the forces of denudation were much more active than they are at present. The numerous oscillations of level that the islands bear evidences of having undergone, and the extensive erosion to which they were afterwards subjected by the combined action of frost and rain, are probably to be accounted among the most potent of the forces that assisted in planing down the islands' rocks, and in distributing the debris throughout the Quaternary and the Recent deposits. The thin integument of soil that covers the surface even in those localities where denudation has been the most severe, masks from view the rocks beneath; and this, combined with the fact that but few clean cut sections of the Lower Coralline Limestone are exposed inland, affords an explanation for the obscurity of these thin veins of black limestone, and for the doubt with which their occurrence in the Malta rocks has hitherto been regarded.

VI.—THE DISCOVERY OF *TEREBRATULINA SUBSTRIATA*, SCHLOTHEIM, IN YORKSHIRE.

By JOHN FRANCIS WALKER, M.A., F.G.S., etc.

SEVERAL years ago Mr. W. H. Hudleston, Prof. J. F. Blake and myself obtained large quantities of *Waldheimia* (*Zeilleria*) *Hudlestoni*, Walker, from the quarry on the Suffield Heights near Scarborough. I had separated several specimens which appeared to differ from the typical form; on rearranging my collection, I carefully examined them, and found that they were covered with fine striæ and also had the characteristic form of the genus *Terebratulina*.

The bed in which they occur is described by Hudleston and Blake, Q.J.G.S. vol. xxxiii. p. 331. This quarry has been long noted for the quantity of small sponges, *Spongia floriceps*, *Spongia corallina*, etc., which it contains. It is to be noticed that Quenstedt "die Brachiopoden," p. 224, states that this brachiopod appears to prefer exclusively a spongy layer as its dwelling place. Quenstedt, *op. cit.* gives the following varieties of *Terebratulina substriata*, var. *alba*, from Weiss Jura, γ, and var. *silicea*, var. *marmorea* from Weiss Jura, δ.

The Yorkshire specimens appear to be most like the variety *Terebratulina substriata*, var. *alba*, but are generally less convex and have the striæ finer and more numerous. If this shell should require a varietal name it might be called var. *Suffieldensis*.

As Mr. S. S. Buckman and myself are preparing a paper on the species of Jurassic Brachiopoda which have been discovered since Davidson's work was completed, I will not further discuss this species. I have presented to the British Museum a specimen of this Brachiopod.

VII.—RECENT OBSERVATIONS ON THE GEOLOGY OF THE LIZARD DISTRICT, CORNWALL.

By ALEXANDER SOMERVAIL, Esq.

DURING a stay of nearly six weeks, made last July and August, at the Lizard, Cornwall, I had ample opportunity of correcting former, and making some fresh observations.

With regard to the first of these, and to some of the strictures recently passed on them, I found that I had little or nothing to regret as to what I had already written on the subject, with the exception of the "felsitic-like-rock" at Housel Cove,[1] which I should now rather regard as a mass segregated, or separated out of the ommon magma, than as an altered portion of the hornblende-schist s I then described it—my object at the time being to show that it vas not a dyke; a view I am still convinced of. I now pass on to ecent observations.

---

[1] GEOL. MAG. Vol. VI. 1889, p. 114.

These latter observations were made over the whole area, that is, rom Polurrian on the west to Porthallow on the east, both of these ocalities marking the boundary between the killas or slates on the iorth, and the igneous rocks of the Lizard district to the south.

I shall briefly localize these observations, beginning with:—

Porthallow.—In the killas or slates here, at a few feet from their unction with the hornblende and serpentine series, there is a uartzose-like-rock at the base of the cliff, immediately below the ron-lode described by Mr. J. H. Collins, F.G.S.[1] The relations of he quartzose-like-rock to the surrounding slates is exactly like hat of an intruded igneous mass, which also in its upper portion ontains included fragments of the slate. On breaking well into this intrusive like rock, its interior is found to present a very lifferent aspect from its exterior; the former is chloritic-like, resembling a diabase that has undergone much alteration. It contains a large amount of iron-pyrites, and recalled to my mind the chloritic rocks of the Start area in Devonshire, especially those near, or at the junction with, the slates in the Bickerton Valley.

Following the cliff towards the Inn, at about 36 paces from which (near a building with outside stair and thatched roof) a gabbro (much decomposed) most unexpectedly occurs, where only the ordinary slates were hitherto supposed to exist. This gabbro has all the appearance of cutting through the slates and the arenaceous beds associated therewith; but on this point I could not arrive at absolute certainty. In the cliff behind the Inn there is also diorite of the greenstone type, but much decomposed. Higher up the road, behind and forming the foundations of the cottages, there is more gabbro and diorite, the former rock cropping out on the roadway and continuing southwards in the direction of the road.

The occurrence of these rocks, where only slates were supposed to exist, is of considerable importance, especially as they seem to rise through the slates, as does also the adjoining serpentine at Pengarrock, which, if the case, when connected with the gabbro and serpentine, and perhaps even the greenstone occurring at Nare Head, Gerran Bay, would clearly prove these Lizard eruptive rocks to be subsequent to the killas. However this may be, the occurrence of the gabbro and diorite or greenstone, forming the cliff described, will necessitate a very considerable alteration of the boundary on the present map.

Returning again to the junction on the coast between the eruptives nd slates, I examined the hornblende-schist which immediately succeeds the serpentine, tracing it along the entire length of the top of the cliff where it has been quarried. It certainly is a very variable rock, in some portions schistose, in others quite massive; in one portion a diorite, in another passing into a variety of greenstone, and other portions with a well-defined porphyritic structure resembling the variety at Porthoustock. In a sentence, there is every grade between a diorite and a greenstone, schistose and massive, non-porphyritic and porphyritic.

---

[1] Quart. Journ. Geol. Soc. vol. 40, 1884, p. 463.

Porthoustock.—Here I examined the greenstone on the extreme south side of the Cove, and found it, as I had done on previous occasions, traceable through many varieties into fine-grained varieties resembling an aphanite, and others into epidiorite, which latter had an apparent passage into the hornblende-schists proper.

Passing over the great alternating succession of gabbro, and greenstone or epidiorite (which I have already described),[1] with the gradual decrease of the latter towards Coverack. there is nothing I have specially to note except a very remarkable and beautiful variety of gabbro occurring as a dyke in the serpentine on the immediate west side of Coverack Pier. The diallage in this gabbro has a brilliant metallic silvery lustre, being quite like a mica at first sight; the only gabbro of the kind that I am acquainted with.

Black Head area.—At a little distance N.W. of Chynhal Point, near the base of the cliff, a diorite dyke one foot in thickness cuts through the serpentine; and at the Black Head, also at the base of cliff, there are two dykes of a similar character in the serpentine which have a N.N.W. and S.S.E. strike or trend.

In this area the serpentine shows evidence of much disturbance, and from this cause, or as a result of cooling, is full of structures; among which is a strongly-marked surface foliation which has the usual N.N.W. and S.S.E. strike which is common to this structure in the serpentine of nearly every locality.

On the west side of Beagle Hole there are two more diorite dykes in the serpentine, and near the Point there is one of gabbro; and two or three more of the latter occur (beside those of Downance and Lankidden Coves already known and recorded) on the west side of Lawn Vinoc. Beside these I have no doubt that careful search would discover many more in what are at present regarded as unbroken masses of serpentine. Passing over a large area I have nothing special to record until near—

Polpeor Cove.—It is here and to the westward that the great development of mica-schist occurs, the origin of which is a problem yet waiting solution. Many appearances would seem to indicate that it is an advanced stage in the metamorphism of the hornblende-schist, for the reasons already given in my former papers.[2] I have only now to add that on extracting a number of lenticular or nodular decomposed masses from the heart of the mica-schist on the west side of the road leading down into the Cove, and on breaking them up their centres were found to consist of the green porphyritic diorite or diabase-like rock so common in the reefs of the Cove. To this may be added the fact that the mica-schist west of Polpeor Cove, at and near the Lizard Point, contains similar nodules of the ordinary hornblende-schist.

---

[1] Geol. Mag. Vol. VI. 1889, p. 425.

[2] Geol. Mag. 1890, Vol. VII. p. 163.

s *Cove.*—To the south-west of the Cove near to Ladan the serpentine there is a dyke[1] or vein of nearly pure ontaining some white mica, biotite, etc., with a nearly north strike.

th to Polurrian Cove.—The Headland of Henscath is by no e most northerly termination of the serpentine, as I found ed in the cliff a little below the level of its top quite con- among the hornblende-schists as far north as Carrag-luz, on each side of the upper portion of the Cove there. There n impure or transitional variety on the south-west side of dn-y-ke which now brings the serpentine within a few yards of Polurrian Cove where the junction occurs between lende and the killas.

REVIEWS.

SYSTEM OF MINERALOGY OF JAMES DWIGHT DANA, 1837– DESCRIPTIVE MINERALOGY (Sixth Edition). By EDWARD BURY DANA, Professor of Physics and Curator of the Mineral ction, Yale University. Entirely Re-written and much rged. Illustrated with over 1400 figures. (London: Kegan Trench, Trübner & Co., Limited, 1892. Royal 8vo. iv. and 1134.)

GEOLOGICAL MAGAZINE, for October, 1868 (Vol. V. pp. -463), we had the pleasure to notice the fifth edition of this uable work, which has been before the scientific world 37, and is likely to continue, for many years to come, the treatise on Mineralogy.

fifth edition the veteran mineralogist, Prof. J. D. Dana, sted in his difficult task by Prof. Geo. J. Brush, and the s then re-written and enlarged to 827 pages.

resent (sixth) edition, issued after an interval of nearly our years, has been entirely re-written and much enlarged ssor E. S. Dana, son of Professor J. D. Dana, and already ly known to mineralogists as the author of a "Text-book alogy," published in 1877 (Trübner & Co.), and noticed in LOGICAL MAGAZINE (Decade II. Vol. IV. 1877, pp. 328–29).

the past quarter of a century the science of Mineralogy le very rapid progress, indeed there has probably never me of more active mineralogical investigation. A striking n of this activity is shown by the many new periodicals, started, devoted largely, if not exclusively, to Mineralogy. ity of mineralogical workers is still further evidenced by hat within the past twenty-four years nearly one thousand es have been introduced into the science—unfortunately, not species," although this has been claimed for most of them. s the important subject of the optical properties of minerals lected, new and improved methods and instruments for

---

locality of this dyke or vein is rather difficult to find, the Serpentine he Cove can guide anyone to it.

stone, and other portions with a well-d
resembling the variety at Porthoustock
every grade between a diorite and a gr
sive, non-porphyritic and porphyritic.

Porthoustock.—Here I examined the
south side of the Cove, and found it
occasions, traceable through many
varieties resembling an aphanite, and
latter had an apparent passage into tl

Passing over the great alternati
greenstone or epidiorite (which I hav
gradual decrease of the latter towa
I have specially to note except a
variety of gabbro occurring as a
immediate west side of Coverack P
has a brilliant metallic silvery lust
sight; the only gabbro of the kin

Black Head area.—At a little
near the base of the cliff, a diori
through the serpentine; and at t
cliff, there are two dykes of a
which have a N.N.W. and S.S.E.

In this area the serpentine sl
and from this cause, or as a re
among which is a strongly-ma
usual N.N.W. and S.S.E. stril
in the serpentine of nearly ev

On the west side of Beagle
in the serpentine, and near th
two or three more of the la
and Lankidden Coves alrea
side of Lawn Vinoc. Besid
search would discover many
unbroken masses of serpent
nothing special to record un

Polpeor Cove.—It is her
development of mica-schist
yet waiting solution. M
that it is an advanced sta
schist, for the reasons alr
only now to add that on
decomposed masses fron
side of the road leading
up their centres were
diorite or diabase-like r
this may be added th
Cove, at and near the
ordinary hornblende-s

in the
mineral
chrysolites,
upon the

the crystallo-
been made to
angles for each
them, and finally
have been calculated
independent means
cases, been calculated
the author hopes that
The Millerian indices

of twinning, and the physical
side, have been carefully
with much fullness, In the
likely to prove useful for a
position of each species. This
of the rare species or those

the order observed in the
abbreviations used, the author
giving as briefly as possible
of crystallization. Each system
of the more important angles
treats of PHYSICAL MINERALOGY—
cohesion; as Cleavage, Fracture,
Specific Gravity or Density. (3)
as Lustre, Colour, Diaphaneity,
optical properties and anomalies.
are then explained. (4) Characters
Magnetism and Electricity. These
that they are treated very briefly
species; references, however, are
papers on the subject.
MINERALOGY: the classification
first, the chemical composition, and
and other physical characters, which
relations of individual species.

---

[1] Ge
[2] Ge

senides, Antimonides.
hantimonites and Sulpho-

Iodides; Fluorides.

nadates; Antimonates; Nitrates.

Tellurates.

: Oxalates, Mellates, etc.
ds.

h good sense in modifying the objection-
l in the fifth edition: such as "Oxyds,"
Arsenids"; but others have been retained:
ritten "Iodyrite"; "Haüynite" is preferred
n" is written "Noselite"; "Sphalerite" is
," although the latter is much better known.
ures as "Halite."

are trivial matters when one considers the
tailed in the careful production of such a monu-

of "Nomenclature" (pp. xl.-xlv.) some excellent
wn, but several of these are more honoured, by
dfathers, in the breach than in the observance as
on of the termination *ite* to proper names in modern
mes of places, persons, etc.), but the making this
syllable a suffix to *common* words in such languages
." The number of such names is, however, far too
ver to hope for their elimination.

s an excellent and concise Bibliography which will be
y convenient to the student.

atalogue of American Localities of Minerals (51 pp.) will
of very great service, forming a useful Gazetteer to many
nown and obscure names of places.

index is excellent and contains over 6000 references.

cannot speak in too high terms of the way in which this new
n of Dana's Mineralogy is produced. The editing has been
ully performed, and the illustrations and typography are
irable. The task must have been one of *extreme difficulty* owing
the great number of tables of figures of measurements of angles,
emical analyses, and abbreviations; and the varieties of types used
hroughout the text.

We congratulate the author on the issue of so excellent a piece of work, which must command a world-wide circulation and be in request wherever Mineralogy is taught.

optical and microscopical study havin
within the reach of all mineralogic
observation have not only increased
constants of many species, but have
to the molecular structure of cryst
also, there has been rapid progress;
way of explaining the composition
of species; again on the analytical si
the development of the synthetic p
methods, in the hands of skilful c
reproduction in the laboratory of n
species, as the felspars, quartz, th
amphibole, corundum, etc.; thus th
composition of species and their form

Great care has been bestowed by
graphic portion of the subject; and
trace back to the original observer
species—then the axes have been rec
the important angles for all comm
from these axes. Where there has b
of verification at hand, the angles ha
a second time independently. In
a fair degree of accuracy has been
have been adopted throughout.

The habits of the crystals, metho
characters, especially those on the
re-written and in general are giv
list of analyses, all are given that
complete understanding of the co
means all reliable analyses in the
of complex composition.

In the Introduction, after expl
description of the species and th
devotes 20 pages to Crystallogra
an explanation of the six system
is carefully illustrated, and tabl
are given. The next subdivision
(1) Characters depending upon
Tenacity, Hardness. Then (2)
Characters depending upon ligh
or degree of transparency; speci
Uniaxial and Biaxial Crystals
relating to Heat; and (5) to
latter characters are so far speci
in this work, under the individu
given to the most important p

The next section is Chemi
adopted in this work follows
secondly the crystallographic
indicate more or less clearly

name: with the Brachiopods we have to translate the names such as *Zeilleria*, *Dictyothyris* and *Eudesia* into the more familiar and customary *Waldheimia* and *Terebratula*. Some of the Gasteropods, such as *Hydatina*, *Diempterus*, *Diartema*, *Chenopus*, *Eustoma*, *Rigauxia*, *Eligmoloxus*, etc., would be wholly unintelligible to most geologists were it not for their places in the lists. Some, at any rate, of these names might have been put in brackets with the more general generic names in front. It is impossible for a student to keep pace with the minor changes of nomenclature, most of which should be *additions* rather than *alterations*; for important as these are to the specialist, they are only a source of ambiguity to others. We do not find fault with M. Rigaux in particular; but we hope that he and others will see, if not the error, at any rate the inconvenience of their ways. For surely the object of scientific work should be to lighten labour, and not unnecessarily to increase it.

It is interesting to note that *Terebratula globata* is recorded from both Great Oolite and Cornbrash, while *Terebratula* (*Dictyothyris*) *coarctata* is given as rare in the latter formation.

The general succession of Oxfordian beds compares well with the strata in this country. There are beds with *Ammonites modiolaris*, and higher stages with *A. Duncani*, *A. Mariæ*, *A. Lamberti*, etc. No doubt, as the author admits, he has included with his Oxfordian division beds that in this country would be classed as Corallian; of these the limestone of Houllefort contains several Corals, *Cidaris florigemma* and other Echinoderms, *Chemnitzia* (*Pseudomelania*) *heddingtonensis*, and other species characteristic of our Corallian rocks. Higher beds are grouped by M. Rigaux as Corallian and Astartian, both of which divisions would also (he admits) be included in our Corallian; although the upper beds show, as in this country, the incoming of Kimeridgian species.

In the Kimeridgian stage are included representatives of Kimeridge Clay and Portland Beds, the latter being, as the author suggests, the littoral facies of the division. In the table at the end of the work the "Portlandian" Beds are, however, grouped separately, but the strata so-called mainly correspond with our Upper Portland Beds.

The fact that each country must have its own minor divisions is shown by the varying characters of the strata and the varying distribution of the fossils.

Thus the 'Gres de la Creche' (which comes beneath marls with *Discina latissima*) yields *Neritoma sinuosa*, *Trigonia Pellati*, *Mytilus autissiodorensis*, *Pterocera Oceani*, *Hemicidaris purbeckensis*, etc. The overlying 'Marnes à *Discina latissima* et *Cardium morinicum* yield *Ammonites biplex*, *Belemnites Souichii*, *Exogyra* (*Ostrea*) *bruntrutana*, *Thracia depressa*, etc. We should be inclined to group these beds with our Lower Portlandian; but M. Rigaux groups only the succeeding 'Marne à *Ostrea expansa*' with the "Portland Sands." The same division is elsewhere marked as 'Marne à *Perna Bouchardi*,' and it contains some of the forms previously mentioned, also *Astarte Sæmanni*, *Cyprina implicata*, *Pecten lamellosus*, *Discina latissima*, and *Lingula ovalis*. The highest Portlandian beds comprise the 'Calcaire

II.—Notice Geologique sur le Bas Bou
Extrait du XIV^{e}. vol. des Mémoires
de Boulogne. 1892.

THIS is the second edition of a work
Society in 1865; it is now revise
additions being due to the labours of Gc
Loriol, and Cossmann. It is, perhaps,
Society to issue a revised edition of a M
in the case before us is one to be comr
regarding a particular area is summarized

The strata exposed in the area include th
Jurassic, and Cretaceous; Silurian rocks
several places beneath the Secondary strat

The author gives an account of the
divisions of each formation, notes the
horizons, and gives some general lists
followed the fashion of subdividing all tl
many respects his plan is more satisfac
clearly stated, and general comparison
fossiliferous horizons in other places by th

The Devonian rocks commence with
includes slates, conglomerates, and gri
(Calcaire de Blacourt) with *Stringocep*
comes the Frasnian stage, divided into
Ferquian sub-stages; they include a serie
with *Spirifer orbelianus*, *Chonetes Douvill*
Streptorhynchus Bouchardi, *S. elegans*, an
the lower division; and *Athyris concentr*
and *Chonetes armata* in the upper divisio
divisions are *Spirifer Verneuili*, *Atrypa re*
stage, the Famennian, includes grits an
bilobatus, *Cucullæa trapezium*, etc.

Carboniferous rocks rest conformably on
two divisions, (1) Limestone, and (2) Coa
ferous Limestone comprises lower beds w
beds with *Productus undatus*, *Spirifer glab*
Terebratula hastata, etc., and upper beds
P. semireticulatus, *Athyris Roissyi*, etc.
shown at the surface in but few locali
much disturbed, and, as proved by bor
places been thrust over them.

Resting directly on the Palæozoic ro
London, there are found strata of Great (
as Bathonian, and representing the upp
(Forest Marble, etc.) and Cornbrash are d
fossils is given.

The Brachiopoda are curiously placed.
of the Oxfordian fossils, between the Fi
We rejoice that the author indexes his Am

of the shell is viewed edgewise the rounded ends of the protoconch may be seen slightly projecting on either side.

The suture line of the first septum is marked by a prominent narrow saddle over the siphuncle, as in the Angustisellati of Branco. According to Mr. Brown's observations, "the total number of main lobes and saddles of the adult shell is apparently developed at the second septum."

The shape of the septa gradually changes from the lunate form of the first septum "into a more and more circular form, until it becomes completely circular in the straight portion of the shell," and in the straight portion, which "begins somewhere between the twentieth and twenty-fifth septa," the form of cross section "passes gradually from a circular to an ovoidal, laterally-compressed form, and finally in the adult into a somewhat triangular form."

"The outer nacreous shell when preserved is found to be marked by minute tuberculations of irregular shape; these in turn give place to the parallel curved lines seen in the adult shell. These parallel lines first appear about the fourteenth septum, and they soon completely obscure the tuberculation. Between the first and second sutures there is apparently an interruption in the growth of the shell, appearing as a line resembling a suture line. This line seems to be slightly raised above the general shell substance; it extends over the end of the ventral lobe of the second suture and back in a simple curve to near the lateral ends of the first suture. In breaking away the nacreous shell substance to follow the sutures, the break nearly always follows this line, leaving the protoconch covered by the original shell. Over the area thus left of the original shell substance the tuberculations are found to be more circular in outline and closer together than in the succeeding portions of the shell. It is believed that the portion of the shell thus bounded represents the original embryonic chamber, or protoconch, which would thus extend beyond the point where the first septum was subsequently developed. A section in the plane of the spiral, but not quite median, showed the shell to be composed of successively deposited layers, and the first of these was seen to extend a short distance beyond the first septum, thus tending to confirm the above belief." An examination of the young of *Scaphites Conradi*, Morton, showed that in this shell also the outer limit of the protoconch was between the first and second septa.

Mr. Brown states that after considerable investigation he is not able as yet to trace the phylogeny of the species. G. C. C.

IV.—The Orthoceratidæ of the Trenton Limestone of the Winnipeg Basin. By J. F. Whiteaves. Transactions of the Royal Society of Canada, Vol. IX. 1891, pp. 77–90, Pls. V.–XI.

THE species here described were, with one exception (from the Nelson River, in Keewatin), obtained in the province of Manitoba, "either from the valley of the Red River (at Lower Fort Garry or East Selkirk), the western shore of Lake Winnipeg, or from some of the numerous islands in that lake." "The term

'Trenton Limestone' is used in a somewhat comprehensive sense, to include all those highly fossiliferous deposits which immediately and conformably overlie the St. Peter's sandstone, and underlie the Hudson River formation." All the specimens are now in the Museum of the Geological Survey of Canada at Ottawa.

The species described are as follows: ***Endoceras annulatum***, Hall, var., *E. subannulatum*, Whitfield, *E. crassisiphonatum*, sp. nov., *Orthoceras Simpsoni*, Billings, *O. semiplanatum*, sp. nov., *O. Selkirkense*, sp. nov., *O. Winnepegense*, sp. nov., *Actinoceras Richardsoni*, Stokes, *A. Bigsbyi*, Bronn, *A. Allumetense*, Billings, sp., *Sactoceras Canadense*, sp. nov., *Gonioceras Lambii*, sp. nov., *Poterioceras nobile*, Whiteaves, *P. apertum*, Whiteaves, *P. gracile*, sp. nov. The species are here given in the order in which the author describes them, which is that adopted by von Zittel in the second volume of his "Handbuch der Palæontologie" (1887); but the genera *Actinoceras* and *Sactoceras* are "regarded as distinct from *Orthoceras*, and *Poterioceras* from *Gomphoceras*."

The most interesting species described in this brief monograph, both for its rarity and peculiar form, is the *Gonioceras*. This is represented by a single, large example, rather more than ten inches long, and having a maximum diameter at the larger end of six inches and a half, and at the smaller end of five inches. It differs from the type of the genus (*G. anceps*, Hall) chiefly in its much greater size, and in the smaller size and peculiar shape of its siphuncle; the septa are also less curved laterally than they are in *G. anceps*. In the latter feature *G. Lambii* is scarcely typical of the genus to which it is assigned; but the compressed lenticular form of the shell, and the position of the siphuncle, justify the author in referring it to *Gonioceras*.

All the species are figured with one exception (*Pterioceras nobile*). Though only outlines, the figures are executed with so much boldness and artistic spirit that the absence of shading can hardly be considered as a serious drawback. A. H. F.

REPORTS AND PROCEEDINGS.

I.—The Royal Society of Canada, Eleventh Annual Meeting, May 30 to June 2, 1892.

FIFTEEN papers were read by Fellows of the Royal Society of Canada at its last meeting, just closed, in Section (IV.) of Geology and Biology, and five more in the Department of Chemistry and Physical Sciences (Section III.).

Of the latter, Professor Chapman's paper "On a New Form of Application Goniometer" is of interest to geologists and mineralogists, as is also his additional note "On the Mexican Type in the Crystallization of the Topaz, with some Remarks on Crystallographic [illegible]tation."

Then comes Professor J. G. MacGregor's address on "The [illegible]ndamental Principles of Abstract Dynamics." Here the independence of Newton's three Laws of Motion is first considered, and an attempt is made to establish it; Maxwell's deduction of the first from the "doctrine of space and time," and Newton's supposed deduction of the third from the first being subjected to criticism.

Geology and Palæontology come in for seven papers, as follows: Presidential Address, by Mr. G. F. Matthew, of St. John, N.B., "On the Diffusion and Sequence of the Cambrian Faunas." In this address an attempt is made to distinguish the littoral and warm-water faunas of the Cambrian age from those which mark greater depths of the sea and cooler water. On the hypothesis that species capable of propagating their kind in the open sea would spread rapidly to all latitudes where the temperature of the sea was favourable, such forms as the Graptolites are taken as fixed points in the successive faunas. The relation to the Graptolites is noted of various species of other groups of animals, as they occur in different countries. It thus seems that several genera appeared first in America, and afterwards spread to Europe. On the other hand, a very close connection no doubt existed between the Cambrian faunas of the north of Europe and those of the Atlantic coast of North America. Hence it is inferred that the temperature of the sea of these two coasts was similar, and the connection between them direct and unimpeded. Equal temperatures in these different latitudes would be maintained by a cold current flowing from the North European to the North Atlantic Coast. The evidence available seems to point to a migration of the American species by a route to the west and north of the main part of the Atlantic Basin.

Mr. Matthew contributed an additional paper, entitled "Illustrations of the Fauna of the St. John Group, No. VII." This is the final paper on this subject, and treats chiefly of the fauna of the highest horizon in the group. It will be accompanied by a list of all the species of the St. John group, showing the several horizons at which they have been found. From the highest horizon itself, the species are of the age of those of the Levis shale, or thereabout, as shown by the Graptolites found here. There are several Orthids, some of which are identical with, or are varieties of, species of the Levis limestone described by Billings. The few Trilobites known are of Cambrian types, and include a *Cyclognathus* allied to *C. micropygus* and a *Euloma*. Several minute Pteropods occur in these shales, with the Graptolites.

Sir William Dawson, F.R.S., presented a paper "On the Correlation of Early Cretaceous Floras in Canada and the United States and on Some New Plants of this Period." The purpose of this paper is to illustrate the present state of our knowledge respecting the flora of Canada in the early Cretaceous, and to notice some new plants from Anthracite, N.W. Territory, collected by Dr. H. M. Ami, and from Canmore, collected by Dr. Hayden. It is a continuation of the author's paper on the "Mesozoic Floras of the Rocky Mountain Region of Canada," in the Transactions of the Royal Society of Canada for 1885.

Sir William then introduced Dr. Ami's paper "On the Occurrence of Graptolites and other Fossils of Quebec Age in the Black Slates of Little Metis, Que." The paper contains notes on, and descriptions of, Graptolites and other fossils from a small but interesting collection made by Sir William Dawson in rocks closely related to those from which the remarkable fossils were described conjointly with Dr. George Jennings Hinde.

Mr. J. F. Whiteaves, palæontologist and zoologist to the Dominion Geological Survey, read two papers, and introduced a third by Mr. Lawrence Lambe. In his first paper on the "Fossils of the Hudson River Formation in Manitoba," Mr. Whiteaves gives an historical sketch of the discovery and collection of fossils of that age, by Dr. R. Bell, in 1873; by Dr. Ells, in 1875; Dr. Bell, later, in 1879; and by Messrs. T. C. Weston and D. B. Dowling, in 1884 and 1891–92, respectively. The object of the present paper is to give as complete a list as possible of the fossils of this formation in Manitoba. There are now as many as sixty species in the museum of the Survey at Ottawa. Mr. Whiteaves's second paper deals with "Notes on the Land and Fresh-water Mollusca of the Dominion." Mr. Lambe's paper contains an account of the results obtained by that gentleman from a microscopical examination of recent sponges collected in the waters of the Pacific, along the British Columbia or Canadian coast. The paper is entitled, "On Some Sponges from the Pacific Coast of Canada and Behring Sea." It will be illustrated with drawings made by the author, who is artist to the Geological Survey Department.

Professor L. W. Bailey, Ph.D., of Frederickton, New Brunswick, gives the result of his "Observations on the Geology of South-Western Nova Scotia," in the counties of Shelburne and Yarmouth. A careful description of the various contacts and occurrences of the auriferous rocks and other masses follows a review of the geological structure of the district in question. A geological map accompanies the paper.

"On Palæozoic Corals" is the title of Professor Chapman's contribution to palæontological science. It is an attempt to simplify the determinations of genera in the so-called "Tabulated and Rugose Corals of Palæozoic Rocks."

Dr. Wesley Mills's paper on "Hibernation and Allied States in Animals."

Dr. George Lawson presented two important contributions to botanical research. The one bore "On the Literary History and Nomenclature of the Canadian Ferns," the other consisted of "Notes Supplementary to the Revision of Canadian Ranunculaceæ."

Rev. Moses Harvey, of St. John's, Newfoundland, and a new Fellow of the Society, contributed a most important paper "On the Artificial Propagation of Marine Food-Fishes and Edible Crustaceans."

Mr. James Fletcher, F.L.S., and Dominion entomologist, contributed two papers in that branch of work. The first was entitled, "Report on a Collection of Coleoptera made on the Queen Charlotte Islands by Rev. J. H. Keen and J. Fletcher"; the second, "The use of Arsenites as Insecticides." H. M. A.

II.—GEOLOGICAL SOCIETY OF LONDON.

June 22nd, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "Contributions to a knowledge of the Saurischia of Europe and Africa." By Prof. H. G. Seeley, F.R.S., F.G.S.

The Saurischia are defined as terrestrial unguiculate Ornithomorpha, with pubic bones directed downward, inward, and forward to meet in a ventral union. The forms of the pelvic bones vary with the length of the limbs, the acetabulum becoming perforate, the ilium more extended, the pubis and ischium more slender, and the sacrum narrower as the limb bones elongate. The order is regarded as including the Cetiosauria, Megalosauria, and Aristosuchia or Compsognatha.

The Cetiosaurian pelvis has been figured in the Quart. Journ. Geol. Soc.; and a restoration is now given of the pelvis in *Megalosaurus, Streptospondylus*, and *Compsognathus*.

The characters of the skull are evidenced by description of the hinder part of the skull in *Megalosaurus* found at Kirtlington, and preserved in the Oxford University Museum. In form and proportions it closely resembles *Ceratosaurus*, and the corresponding region of the head in Jurassic Ornithosauria. The brain-cavity and cranial nerves are described, and contrasted with those of *Ceratosaurus*.

The skull in Cetiosauria, known from the American type *Diplodocus*, is identified in the European genus *Belodon*, which is regarded as a primitive Cetiosaurian.

Part 2 discusses the pelvis of *Belodon*, restored from specimens in the British Museum, and regarded as Cetiosaurian. A restoration of the shoulder-girdle is made, and found to resemble that in Ichthyosaurs, Anomodonts, and Dinosauria. The vertebræ in form and articulation of the ribs are Saurischian, the capitular and tubercular facets being vertical in the dorsal region, and not horizontal as in Crocodiles. The humerus shows some characters in common with that of *Stereorachis dominans* in the epicondylar groove. In general character the limb-bones are more Crocodilian than the axial skeleton. The interclavicle is described, and regarded as a family characteristic of the Belodontidæ.

In the 3rd part an account is given of *Staganolepis*, which is regarded as showing a similar relation with the Megalosauria, to that of *Belodon* with the Cetiosauria. This interpretation is based chiefly upon the identification of the pubic bone in *Staganolepis*, which has the proximal end notched as in *Zanclodon* and *Streptospondylus*; and the inner ridge at the proximal end is developed into an internal plate. A note follows on the pelvis of *Aëtosaurus* which is also referred to the Saurischia on evidence of its pelvic characters, approximating to the Cetiosaurian sub-order.

Part 4 treates of *Zanclodon* which is regarded as closely allied to *Massospondylus, Euskelesaurus*, and *Streptospondylus*. It is founded chiefly on specimens in the Royal Museum at Stuttgart, and in the University Museum at Tübingen. The latter are regarded as possibly referable to *Teratosaurus*, but are mentioned as *Zanclodon*

Quenstedti. The pelvis is described and restored. *Zanclodon* has the cervical vertebræ relatively long, as compared with *Megalosaurus*, and small as compared with the dorsal vertebræ, which have the same Teleosauroid mode of union with the neural arch as is seen in *Streptospondylus* and *Massospondylus*. The sternum, of Pleininger, is the right and left pubic bones; but there is much the same difference in the proximal articular ends of those bones in the fossils at Stuttgart and Tübingen, as distinguishes corresponding parts of the pubes in *Megalosaurus* and *Streptospondylus*. The ilium is more like that of *Palæosaurus* and *Dimodosaurus*. The limb-bones and digits are most like those of *Dimodosaurus*, but the teeth resemble *Palæosaurus*, *Euskelesaurus*, *Megalosaurus*, and *Streptospondylus*.

Part 5 discusses *Thecodontosaurus* and *Palæosaurus* upon evidence from the Dolomitic Conglomerate in the Bristol Museum. An attempt is made to separate the remains into those referable to *Thecodontosaurus* and those belonging to *Palæosaurus*. The latter is represented by dorsal and caudal vertebræ, a scapular arch, humerus, ulna (?), metacarpals, ilium, femur, tibia, fibula, metatarsals, and phalanges. These portions of the skeleton are described. There is throughout a strong resemblance to *Zanclodon* and other Triassic types. A new type of ilium, and the humerus originally figured are referred to *Thecodontosaurus*.

Part 6 gives an account of the South African genus *Massospondylus*. It is based partly upon the collection from Beaucherf, in the Museum of the Royal College of Surgeons, referred to *M. carinatus*; and partly upon a collection from the Telle River, obtained by Mr. Alfred Brown, of Aliwal North, referred to *M. Browni*. The former is represented by cervical, dorsal, sacral, and caudal vertebræ; ilium, ischium, and pubis; femur, tibia; humerus, metatarsals, and phalanges. The latter is known from cervical, dorsal, and caudal vertebræ, femur, metatarsals, and bones of the digits. The affinities with *Zanclodon* are, in some parts of the skeleton, stronger than with *Euskelesaurus*.

Part 7 gives an account of *Euskelesaurus Browni*, partly based upon materials obtained by Mr. Alfred Brown from Barnards Spruit, Aliwal North, and partly on specimens collected by the author, with Dr. W. G. Atherstone, Mr. T. Bain, and Mr. Alfred Brown, at the Kraai River. The former series comprises the maxillary bone and teeth, vertebræ, pubis, femur, tibia and fibula, phalanges, chevron bone and rib. The latter includes a cervical vertebra and rib, and the lower jaw. The teeth are stronger than those of *Teratosaurus*, or any known Megalosaurian. The anterior part of the head was compressed from side to side, and the head in size and form like *Megalosaurus*, so far as preserved. The pubis is twisted as in *Staganolepis* and *Massospondylus*, with a notch instead of a foramen at the proximal end, as in those genera; and it expands distally after the pattern of *Zanclodon*. The chevron bones are exceptionally long, and the tail appears to have been greatly elongated. The femur is intermediate between *Megalosaurus* and *Palæosaurus*, but most resembles *Zanclodon* and *Massospondylus*. The tibia in its proximal end resembles many Triassic genera; and in its distal end is well distinguished from *Massospondylus* by its mode of union with the astragalus. The claw-phalanges are convexly rounded, being wider than is usual in Megalosauroids. The lower jaw from the Kraai River gives the characters of the articular bone, and the articulation, as well as of the dentary region and teeth. The cervical vertebra is imperfect, but is remarkable for the shortness of the centrum, being shorter than in *Megalosaurus*.

In Part 8 an account is given of *Hortalotarsus skirtopodus* from Barkly East, preserved in the Albany Museum. It is an Euskelesaurian, and exhibits the tibia and fibula, and tarsus. There is a separate ossification for the intermedium, which does not form an ascending process; and the astragalus is distinct from the calcaneum. The metatarsals are elongated, and the phalanges somewhat similar to those of *Dimodosaurus*.

Part 9, in conclusion, briefly examines the relations of the Saurischian types with each other, and indicates ways in which they approximate towards the Ornithosauria. It is urged that the Ornithosauria are as closely related to the Saurischia as are the Aves to the Ornithischia; and that both divisions of the Saurischia approximate in *Staganolepis* and *Belodon*. Finally, a tabular statement is given of the distribution in space and time of the 25 Old-World genera which are regarded as probably well established. Eight of these are referred to the Cetiosauria, thirteen to the Megalosauria, and four to the Aristosuchia or Compsognatha.

2. "Mesosauria from South Africa." By Professor H. G. Seeley, F.R.S., F.G.S.

The author gives an account of specimens of *Mesosaurus pleurogaster* (Seeley) obtained from the shales at the Kimberley diamond-mine. They are of small size, and show generic identity with the Paris type, but indicate an animal with a long tail, with the hind limbs well developed. The centra of the vertebræ are barrel-shaped, contracting to the articular faces, which are conically cupped. The dorsal ribs have the usual subcylindrical character and development; but the abdominal armour is more like that of a Plesiosaur, only the sternal ribs are thin and flat. The vertebræ appear to give attachment to the dorsal ribs in an unusual way, which suggests the condition in the Theriodontia, but without distinct tubercles or facets; so that the slender head of the rib lies in the depression between two centrums. In the early caudal vertebræ the transverse processes are stronger, the neural spines long and compressed, and chevron bones well developed. Details are given of the structure of the tarsus and hind limb.

A new example of *Mesosaurus tenuidens* from Albania, preserved in the South African Museum, shows many details of structure more perfectly than in the type-specimen; and the author describes the skull, cervical and dorsal vertebræ, shoulder-girdle, ribs, and fore limbs. The forms of the cervical ribs are determined, and the composite structure of the scapular arch shown to have characters in common with that of *Dactylosaurus*, *Stereosternum*, and *Plesio-*

saurus. The humerus closely resembles that of the edentate *Megalonyx* before its epiphyses are ossified. There are four bones in the distal row of the carpus, and three bones in the proximal row. The characters of the dorsal surface are given from a specimen preserved in the Albany Museum.

The author then discusses the relation of *Mesosaurus* to *Stereosternum*, as preserved in the British Museum, arriving at the conclusion that the two genera are distinct, defined by characters drawn from all parts of the skeleton. *Stereosternum* has four sacral vertebræ, with the ilium extended far in front of the acetabulum. The coracoids are regarded as meeting in the median line, and not by overlap as in the thin ossification of *Mesosaurus*. In both genera there are five bones in the distal row of the tarsus.

The author concludes that these types are closely allied to *Neusticosaurus*, which he would separate from the Nothosauria and unite with the Mesosauria. That group is subdivided into two divisions—the Proganosauria of Baur, and the Neusticosauria; the former being known from South Africa and South America, and the latter from Europe only.

3. "On a New Reptile from Welte Vreden, *Eunotosaurus africanus* (Seeley)." By Prof. H. G. Seeley, F.R.S., F.G.S.

The author obtained the specimen described at Welte Vreden, near Beaufort West, Cape Colony, where it was found by Mr. L. Pienaar in beds of Middle Karoo age. It indicates a small animal, and shows the dorsal ribs, vertebræ, and part of the pelvis. The centra are more slender than in any known South African fossil, and conically cupped at the ends as in *Mesosaurus*, etc. There is no indication of great transverse widening of the neural arch. The neural spine is compressed. The ribs appear to have been attached much as in Chelonians, though the articulation is not seen. They are remarkably massive, long, wide, compressed above, and subtriangular in transverse section. There may be some sternal ribs. The os pubis is thin and flattened, with a notch on the outer hinder border like that seen in Mesosauria. The genus is probably referable to that group, but distinguished from all known genera by the form of the vertebræ and ribs.

4. "The Dioritic Picrite of White Hause and Great Cockup." By J. Postlethwaite, Esq., F.G.S.

The rock, which is about two miles N.E. of the Little Knott rock, formerly described by Prof. Bonney, was referred to by the author as "a large mass of hornblende picrite of like nature" to the Little Knott rock, in a paper published in the 'Transactions' of the Cumberland and Westmoreland Association for 1889–90. Microscopic examination by Prof. Bonney of the rock which is the subject of the present communication confirms this determination.

The metamorphism observable around this mass is considerably larger than that seen round the Little Knott mass.

5. "On the Structure of the American Pteraspidian, *Palæaspis* (Claypole), with remarks on the Family." By Prof. E. W. Claypole, B.A., D.Sc., F.G.S.

After reviewing the discovery of *Palæaspis* and noticing cases ere Scaphaspid plates had been referred to ventral plates of eraspidian fish, the author describes two specimens of his genus *læaspis* from the Onondaga group (referred to the Lower Ludlow) ich indicate the existence of a ventral plate in this genus. The idence in favour of this interpretation is given at length, and the sil originally described as *P. bitruncata* is maintained to be the aphaspid plate of *P. americana*.

The existence of lateral plates and of lateral organs ('fins') is o discussed, and a comparison made between *Palæaspis* and other eraspids. The author attempts a restoration of *Palæaspis*, and ves an amended definition of the genus.

6. "Contributions to the Geology of the Wengen and St. Cassian rata in Southern Tyrol." By Maria M. Ogilvie, B.Sc. (Commu-ated by Prof. C. Lapworth, LL.D., F.R.S., F.G.S.)

In the first part of this paper the authoress gives a summary of evious investigations and speculations respecting the sequence and ssils of the Triassic rocks of the well-known Dolomitic region of uthern Tyrol; more especially with reference to the famous fossil-aring strata of the neighbourhood of St. Cassian. The different ews which have been advanced with regard to the actual mode of mation of these strata, and their proper classification, since the pearance of the classical works of Von Richthofen and Mojsisovics, e indicated, and their geological significance discussed.

In the main body of the paper the authoress gives a generalized count of the results of her own personal study of these strata ring the years 1891–1892, illustrating her conclusions by maps and ctions. Three areas have been partly mapped in detail, on the le of 1 : 25000, and the various fossiliferous zones have been ced on the ground. The range and nature of the faults, etc., ve in this way been determined.

The typical area of Prelongei and St. Cassian is first described in tail, and from a careful mapping of the ground and a study of e fossils the authoress reaches the conclusion that the St. Cassian ata are naturally separable into three divisions, viz:—

1. *Upper Cassian Beds* (or *Prelongei Zone*).
2. *Middle Cassian* (or *Muren Zone*).
3. *Lower Cassian* (or *Stoures Zone*).

Each division is characterized by certain special lithological atures and palæontological characters, everywhere recognizable. opposition to the views of some other investigators, it is shown, physical and palæontological evidence that the Upper Cassian ries is normally succeeded, as originally asserted by Von Richthofen, the well-known Schlern Dolomite, and that between this band d the massive Dachstein-Kalk there is invariably found the peculiar ne of the Raibl strata.

The physical and palæontological relationships of the disputed rata of the Richthofen Riff and Sett Sass are next discussed. The hly fossiliferous strata of Heiligenkreuz are shown to include rocks belonging to all the three zones of St. Cassian, and a part also of the Raibl. Detailed descriptions and illustrations of the disposition of the strata near Cortina d'Ampezzo, Seeland Thal, the Seisser Alpe, etc., are given; and in all cases it is shown that the order recognized in the St. Cassian-Prelongei area is retained practically unmodified, and can be satisfactorily correlated with that of the Upper Trias of the Bavarian Alps.

7. "Notes on some New and Little-known Species of Carboniferous *Murchisoniæ*." By Miss Jane Donald. (Communicated by J. G. Goodchild, Esq., F.G.S.)

In a previous paper the various sections into which it has been considered advisable to group different species of ***Murchisonia*** have been noticed. Of the species described in the present communication, two only can be undoubtedly referred to ***Goniostropha*** of Œhlert. Others have the sinus situate above the angle: and if this position of the sinual band be considered sufficiently distinctive, the authoress suggests the name ***Hypergonia*** for this section, and takes ***Murchisonia quadricarinata*** as the type.

The following new forms are described:—***Muchisonia*** *(Goniostropha) hibernica*, ***M.*** *(G.) Tatei*, ***M.*** *(Hypergonia) quinquecarinata*, De Kon., var. *pulchella*, ***M.*** *(H.) conula*, De Kon., var. *convexa*, ***M.*** *(H.) pentonensis*, ***M.*** *(H.) Kirkbyi*, ***M.*** *(H.) plana*, ***M.*** *(Cœlocaulus?) tædia*.

A fuller description is also given of a species previously described by Prof. Haughton under the name of *Cerithioides telescopium*.

8. "Notes from a Geological Survey in Nicaragua." By J. Crawford, Esq., State Geologist to the Nicaraguan Government. (Communicated by Prof. J. Prestwich, LL.D., F.R.S., F.G.S.)

Nicaragua, geologically considered, can be divided, from north to south, into five zones, differing from one another in lithological, mineralogical, and structural characters.

The first division embraces the central mountainous parts, and contains Laurentian, Taconian, Cambrian, and Silurian rocks, also Devonian rocks unconformable to the last. The second division, parallel to that just named, and extending to within a hundred miles of the Caribbean sea, contains sediments of Carboniferous, Permian, and Mesozoic ages, covered unconformably by Cainozoic and modern formations. In some of the rivers of this division are rich gold-placers. The third division is the delta on the eastern coast. Evidence furnished by alluvial deposits and coral-reefs indicates recent subsidence until a few years ago, when elevation commenced. The fourth division is on the western side of the first (central) division. Its rocks are generally similar to those of the second division. In some places dykes are connected with lava-flows. In the valley of the Rio Viejo is a Tertiary mammaliferous deposit with Tillodonts, etc. The fifth division occupies Western Nicaragua, and contains several small crater-lakes of the Vicksburg, Yorktown, and Sumpter periods; all the post-Mesozoic Nicaraguan volcanoes are in this division.

Details of the economic products, the volcanic phenomena, and the glaciation of the country are furnished, and the remains of Neolithic man are recorded.

9. "Microzoa from the Phosphatic Chalk of Taplow." By F. Chapman, Esq., F.R.M.S. (Communicated by Prof. T. Rupert Jones, F.R.S., F.G.S.)

Ninety-eight species and varieties of Foraminifera, and five species and varieties of Ostracoda have been found in this deposit. All the forms of Ostracoda have been previously found in the Chalk. Of the 98 varieties of Foraminifera five appear to be new, whilst altogether thirty are new to the Chalk fauna.

The following new forms are described:—*Nubecularia Jonesiana, Textularia decurrens, T. serrata, Bulimina trigona*, and *Bolivina strigillata*.

10. "On the Basalts and Andesites of Devonshire, known as Felspathic Traps." By Bernard Hobson, Esq., M.Sc., F.G.S.

The evidence in favour of the contemporaneous (non-intrusive) character of these Permian (or Triassic) lavas is discussed, and the improbability of the former existence of felspathic traps in the area of the Dartmoor granite, as suggested by Mr. R. N. Worth, is shown. The macroscopical and microscopical characters of the rocks are described. The great majority of the rocks examined are olivine-basalts, though mica-augite-andesite occurs at Killerton, near Exeter. The presence of quartz-inclusions in the rocks of West Town, Knowle, etc., near Exeter, is shown to have misled De la Beche into terming these rocks quartz- ('quartziferous') porphyries. The veins in the traps, mentioned by Mr. Vicary, and regarded by some authors as intrusive felsite dykes, are found to be red-stained veins of calcite and sandstone.

11. "Notes on Recent Borings for Salt and Coal in the Tees Salt-District." By Thomas Tate, Esq., F.G.S.

The Tees Salt industry has expanded considerably since Mr. E. Wilson's exhaustive paper was read in June, 1888.

The results of subsequent borings have in most cases simply confirmed previously ascertained facts, but the two boreholes with which this paper principally deals, put down on the White House estate, three miles due west of Stone Marsh, may be useful in relation to the determination of (*a*) the area of the Tees Salt-field, and (*b*) the southern limit of the Durham Coal-basin.

After boring through 115 feet of Drift deposits and 151 feet of Red Sandstones and Marls, the Saliferous Marls, at the base of which the Salt-rock, when present, is usually found sandwiched between two beds of anhydrite, were reached, having a thickness of 178 feet, but with no Rock-salt. The Magnesian Limestone formation, only 299 feet thick, an unusually large proportion of which is gypsum or anhydrite, was succeeded by grey sandstones, rich in calcite, probably due to infiltration. The carbonaceous shales and sandstones with bands of encrinital limestone below these, together with their contained fossils, determine their identity with the Yoredale Series. Total depth, 1079½ feet.

The chief results are:—(1) the Upper Keuper Red Marls are wanting (as in nearly every borehole north of the Tees); (2) the Salt-rock is absent and the Red Marl overlying its horizon is not 'rotten marl' but compact; (3) the Magnesian Limestone (299 feet) is the thinnest complete section in County Durham; (4) no coal is found; (5) the Yoredale Rocks are represented by 336½ feet of grey sandstones and encrinital limestones, carbonaceous shales, ironstone nodules and carbonaceous sandstones.

An Appendix, containing full details of the two vertical sections, accompanies the paper.

CORRESPONDENCE.

◆

CONCRETIONS.

SIR,—Is not carbonic acid evolved from decaying organisms? If lime were present in the water in which such decomposition were taking place, would not the acid combine with the base to form a carbonate of lime?

Would not the precipitation of this salt first take place immediately around the organic nucleus, and form a covering which would enclose the decomposing matter? This covering would not only retard future chemical action, but would confine it to a much narrower limit, viz. the centre of the embryonic concretion.

But as the decomposition of the organic matter would not necessarily at this stage be arrested, would not the CO_2 gradually ooze through the thin crust, and the chemical action continue, though more slowly, as before, causing a gradual thickening of the concretion through external precipitation.

The greater the distance from the nucleus, the weaker would this action become, and the concretion would finally reach a point at which—owing either to a failure in the supply of the CO_2, or the inability of the same to penetrate the increased thickness of $CaCO_3$—it would cease to grow.

Would not this theory account for the formation of *Sphæosiderites*, and other nodules containing organic nuclei? Would it not also explain why these so often increase in hardness towards their centres?

C. C. W.

MISCELLANEOUS.

◆

YORK MUSEUM.—We learn from York that the late Mr. William Reed, F.G.S., whose obituary notice we published in our June Number (p. 283), has most generously bequeathed to the Yorkshire Philosophical Society the sum of £600 the interest of which is to be expended on the Museum which has already been so greatly enriched by the various donations of collections presented by Mr. Reed in past years.

VERTICAL SECTION OF STRATA AT KHARKOV, SOUTH RUSSIA, DISPLAYED BY ARTESIAN BORING.

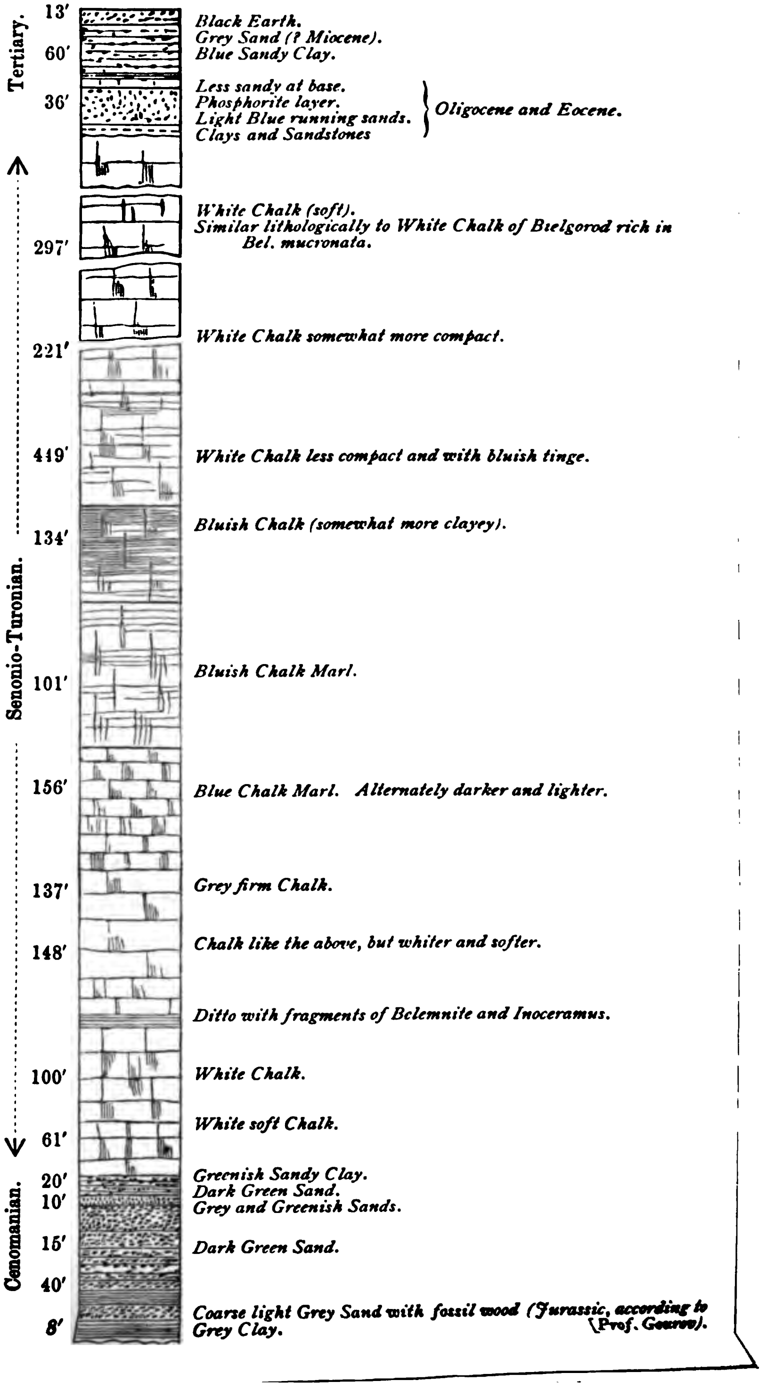
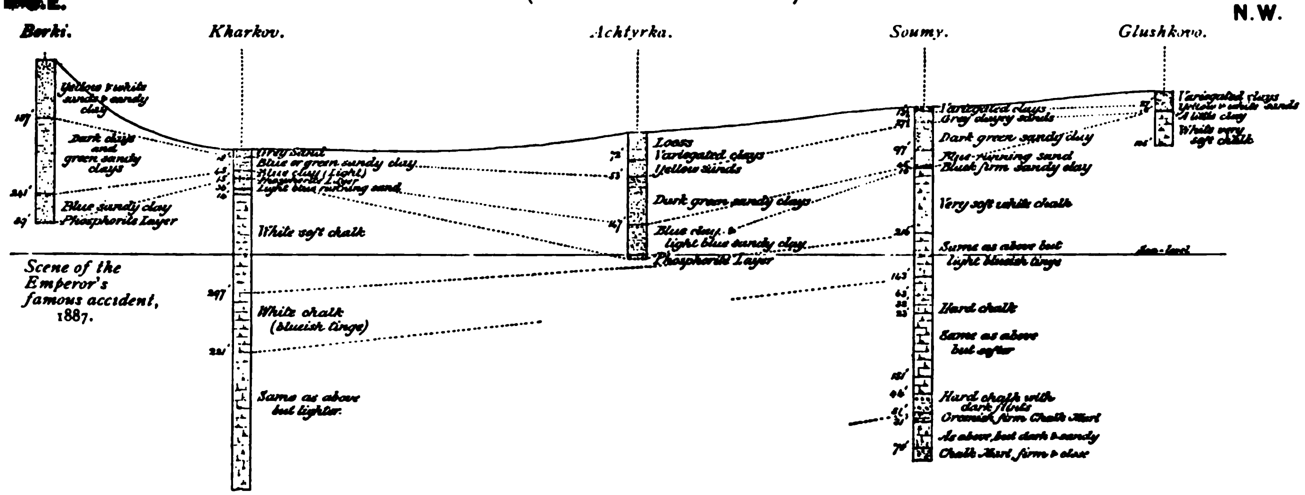

Tertiary.
13′
60′
36′
Black Earth.
Grey Sand (? Miocene).
Blue Sandy Clay.
Less sandy at base.
Phosphorite layer.
Light Blue running sands.
Clays and Sandstones
Oligocene and Eocene.
Senonio-Turonian.
297′
White Chalk (soft).
Similar lithologically to White Chalk of Bielgorod rich in Bel. mucronata.
221′
White Chalk somewhat more compact.
449′
White Chalk less compact and with bluish tinge.
134′
Bluish Chalk (somewhat more clayey).
101′
Bluish Chalk Marl.
156′
Blue Chalk Marl. Alternately darker and lighter.
137′
Grey firm Chalk.
148′
Chalk like the above, but whiter and softer.
Ditto with fragments of Belemnite and Inoceramus.
100′
White Chalk.
61′
White soft Chalk.
Cenomanian.
20′
Greenish Sandy Clay.
10′
Dark Green Sand.
Grey and Greenish Sands.
15′
Dark Green Sand.
40′
Coarse light Grey Sand with fossil wood (Jurassic, according to Prof. Gourov).
8′
Grey Clay.

FIG. 2.—LONGITUDINAL SECTION FROM BORKI TO GLUSHKOVO, THROUGH KHARKOV AND SOUMY (MARKED a—b ON THE MAP).



Scale :—
Vert. 1″ = 320′
Horiz. 1″ = 25 *versts or kiloms.*

Details of bore continued in special figure.

Order of Tertiary Beds.
1. *Variegated clays.*
2. *Sands (yellow and white).*
3. *Green sandy clays.*
4. *Blue clay.*
5. *Phosphorite layer.*
6. *Blue running sand.*
7. *Dark firm clay.*

Compare with Tertiary at Kieff.
1. *Variegated clays (probably late Pliocene).*
2. *White sands (? Miocene).*
3. *Glauconitic sands with Amber as at Königsberg.*
4. *Blue Spondylian clay (Eocene).*
5. *A Phosphorite layer has been noted.*
6. }
7. } *Probably not represented.*

The Phosphorite layer is especially to be noticed, as it has not been previously shown to extend over any very wide area. Prof. Armachevsky called attention to it at Putivel, but the borings show it to cover a wide space in the Kharkov and Poltava Governments. The Chalk is never more than a 100 feet below this layer.

To illustrate Mr. Hume's paper on Russian Geology.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IX.

No. IX.—SEPTEMBER, 1892.

ORIGINAL ARTICLES.

I.—NOTES ON RUSSIAN GEOLOGY.

By W. F. HUME, B.Sc., A.R.S.M., F.G.S.;
Demonstrator in Geology, Royal College of Science.

PLATES X. AND XI.

CRETACEOUS.

IN the summer of 1891 a journey was undertaken by the writer to the S.W. Governments of Russia, the immediate object in view being the study of the geology of that region. This portion of the notes then taken will deal more especially with the extent, thickness, and general contour of the Cretaceous beds of the district, together with a review of the Russian literature bearing on the zonal distribution in the various Governments.

In 1845 Murchison had gathered together most of the facts then known regarding the Cretaceous formation of S. Russia, but his own direct observations were few, and the work was considered of only secondary importance. Under these circumstances it would not have been very surprising to find that he had fallen into error on many points.

In discussing the Chalk of the Donetz Basin, Murchison had already pointed out the great resemblance of the Russian beds to their W. European representatives, both in their faunal and lithological characteristics, and subsequent research has shown that it is possible to arrange the strata into divisions corresponding to those adopted by French authors.

The main discussion will be restricted to the governments of Kieff, Poltava, Tchernigov, Kursk, and Kharkoff; these districts being those which came most under my immediate notice. In addition to numerous personal visits to the finest exposures, I had the further advantage of being supplied by Messrs. Winning Brothers, of Kharkoff, with detailed copies and a few samples of the principal bores worked by them during the last few years. Amongst these the bore at Kharkoff reveals the greatest thickness of Chalk yet known in Europe (Plate X. Fig. 1). Taking this city as a centre, a section, running from Gluskhovo through Soumy and Achtirka to Kharkoff, and thence to Borki may be constructed from the data to hand.

The heights of the principal localities may be easily correlated with the level of the Chalk beneath the surface:—

	Height, feet.	
Gluskhovo	511	... Chalk 78 ft. below surface.
Soumy ...	488·3	... Chalk 147–199 ft. below surface.
Achtyrka	402·08	... Not reached at 454 ft. (Phosphorite layer only reached).
Kharkoff	354·2	... Chalk reached at 132·9 ft.
Borki ...	636·51	... Not reached at 529 ft. (Phosphorite layer).

(See Plate XI. Fig. 2).

It will be evident by mere inspection that the following general points may be observed in Fig. 1 and 2: first, that the Tertiary beds are divisible into two main divisions (1) an Upper, more sandy division; (2) a Lower, more clayey division; second, that the Chalk strata are divisible into three main lithological divisions (1) a pure white Chalk, in the main soft; (2) a more marly Chalk; (3) a firm, hard Chalk. Finally there is at the base a greensand, as in England, followed by a few grey clays and sands.

Secondly, it will be seen that the thickness of the Chalk strata at Kharkoff alone almost doubles that in the London and Paris Basins.

A closer analysis of the Kharkoff bore yields the following details of structure (the 133 feet of Tertiary beds are not at present discussed):

	Feet	in.		Feet	in.
White soft Chalk	297	0	Grey firm Chalk (more clayey)	7	3
Ditto (more bluish)	221	0	White Chalk	100	0
Ditto (less blue)	449	0	Ditto soft	61	0
Ditto (somewhat clayey) ...	134	0	Ditto hard (with glauconite)	3	0
Bluish Chalk Marl	101	0	Green sandy clay	20	0
Ditto (darker and lighter) ...	156	0	Grey sand	4	3
Grey firm Chalk	137	0	Hard bound grey sand	1	9
Ditto (more white and soft)	148	0			
Ditto (with fossils)	7	0			
Fragments of a Belemnite and Inoceramus.					
Ditto (with green clayey bed)	10	0			

After these follow green and grey sands, alternating with dark sandy clays.

At a depth of 2107 ft. 8 in. below the surface fossil wood was met with in a coarse grey sand.

In the Soumy bore there is less detail (Tertiary beds here 200 feet thick).

Very soft white Chalk ... ... 216 feet 6 inches.
3 ft. 6 in. firm bed between.
Ditto (light bluish) ... ... 143 feet.

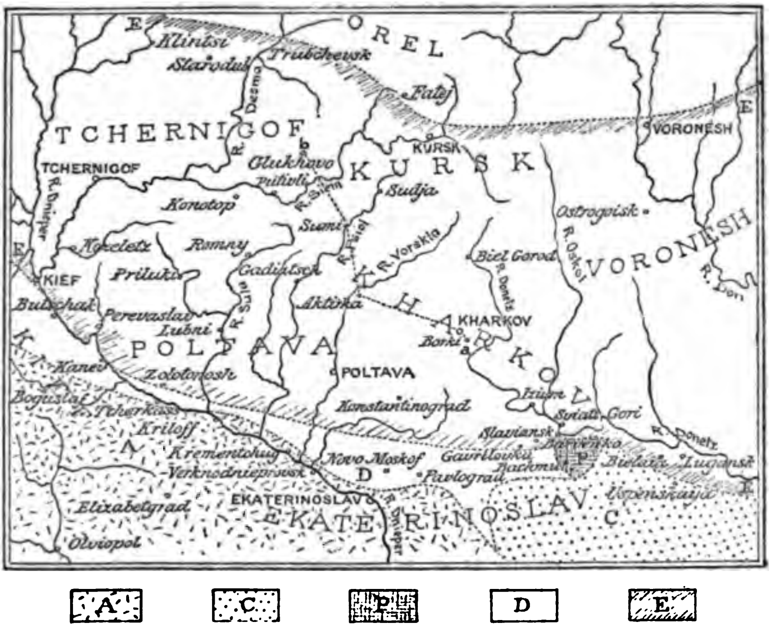
Then follow a series of alternations of hard and soft Chalk beds, to a depth of 954 feet. At 898 feet there is a very hard bed with bluish sandy balls, and at a depth of about 900 feet dark flints make their appearance in a hard Chalk bed. Below this hard bed (50 feet thick) commences the Chalk Marl, the latter being over 150 feet thick when the boring ceased. In the Glushkovo bore (excluding 78 feet of Tertiary and later beds) 105 feet of clean soft white Chalk were passed through before the boring was finished.

Although the want of fossils is marked, and the outcrops are few and far between, it may yet be possible to obtain a few details as to the faunal characters of the beds. For this purpose I undertook a journey to Bielgorod, 75 versts to the N. of Kharkoff, visiting as many quarries as it was possible during the time at my disposal.

The beds evidently correspond to the highest series in the above tables, as they are soft white Chalk, and immediately underlie the Green Tertiary Sandstones. These beds yielded a most abundant crop of *Belemnitella mucronata*, but beyond these, and a fragment of a thin-shelled *Inoceramus*, no other forms were obtained.

Prof. Armachevsky, who has been engaged in the task of mapping the northern portion of the area now under discussion, has examined the exposures of Chalk and Chalk Marl displayed in the courses of the Rivers Siem and Psiol. (A large number of localities are given by him which I need not mention here). The strata consist in the main of a white, massively-jointed Chalk, Chalk Marl only cropping out in the N.E. corner, towards Kursk. The following fossils occur in the first-named: *Cidaris vesiculosa*, *Echinocorys ovata*, *Terebratula carnea*, *Ostrea vesicularis*, and *Pecten splendens*.

MAP OF SOUTH RUSSIA (CENTRAL PORTION) REFERRED TO IN PAPER.



A *Archæan (Gneisses and Granites).*

C *Carboniferous (Shales, Sandstones and Limestones).*

P *Permian.*

D *Doubtful (in this area Cretaceous, Jurassic, and Carboniferous have been met with).*

E *Approximate Boundary of Upper Cretaceous.*

The Tertiary Beds covering a large part of the country are treated as though they had been denuded away.

a *to* b *indicates Line of Section on Map.*

In the Tchernigov Government to the N.W. a large series of fossils have been met with, but they seem to show that the zonal arrangement holds far less for this E. end of the European

Cretaceous basin. At the same time most of the genera are the same as those occurring in the English Chalk, and the results may be analysed as follows:

		IN WESTERN EUROPE.
Common or mixed forms	*Ostrea vesicularis* ...	Whole Upper Cretaceous.
	,, *flabelliformis* ...	Turonian and Senonian.
	Spondylus spinosus ...	Ditto ditto.
	Parasmilia centralis ...	Ditto ditto.
Senonian forms ...	*Echinocorys ovata* ...	*Belemnitella mucronata* Zone.
	Terebratula carnea ...	Do. and Micr. cor-anguinum Zone.
	Magas pumilus ...	*Belemnitella mucronata* Zone.
	Belemnitella mucronata	Ditto.
	Pecten undulatus ...	Marsupites Zone.
	Many Ventriculites.	
And probably most of the Fish remains ...	...	*Beryx, Corax, Ischyodon*, etc.
Cenomanian forms ...	*Cidaris vesiculosa* ...	*Pecten asper* and Chloritic Marl.
	Serpula gordialis ...	*Pecten asper.*

It will be seen from the above list that by far the greater number of the fossils obtained belong to the higher beds of the Upper Cretaceous in W. Europe, and it is therefore, on the whole, perhaps advisable to conclude that the White Chalk and Chalk Marl represent a Senonio-Turonian series in which divisions are not sharply marked off as with us.

Summing up then, we may conclude that the Cretaceous beds are cropping out in the following order from S. to N.:

1. Chalk (white and soft, in N. Kharkoff Government). 2. Chalk Marl (in S. of Kursk Government). 3. The phosphoritic grits of Kursk, which have been shown to be Cenomanian by the Russian geologists, and which crop out some five versts N. of the above town. A few words may also be of interest as to the work done with regard to these beds in the Governments on the N.E. and E. of the Kharkoff Government.

In the Saratov Government Prof. Sintzoff has noticed two upper Cretaceous divisions—a sandy and a marly or chalky division; passing into one another by gradual lithological change; he divides the latter again into (1) Chalk; (2) Chalk Marl; (3) Sponge beds, with numerous remains of sponges. (This has not been met with in the Kharkoff bore.) The same Professor has again remarked for the Simbirsk Government that there are two main divisions, viz.: Chalk and Chalk Marl, inseparable from one another, both on palæontological and stratigraphical grounds. Below this occurs glauconitic chalk, with phosphatic nodules. In the above views Professor Lagusen concurs. Professor Sintzoff has also come to the conclusion that the fauna of these beds is a mixture of Senonian and Turonian forms. Professor Lagusen has remarked that the fauna of Simbirsk is mainly Senonian, but at the same time Turonian forms occur, and this condition holds for other Governments, wherever studied (Voronesh, Don Cossack country, Kursk, Kharkoff, and Ekaterinoslav).

Prof. Borusak also has divided these beds into White chalk, Chalk Marl, and Glauconitic marly sandstones. For the Kursk Government Hofmann has shown that the famous phosphorite grit or

Northern Bone Bed of Kiprianov contains numerous sponges (*Porospongia, Cribrospongia concentrica*), and has referred these to the Cenomanian.

In the Chalk Marl he found *Ostrea carinata, O. canaliculata*, etc., and referred it to the *Turonian*, and finally the soft chalk with flints and *Belem. mucronata, O. vesicularis*, and *O. semiplana* he considered Senonian. (These results must, however, be modified as shown above.)

2nd. The development of the Cretaceous Basin to the west of the central area may next be considered. Data from borings are very scarce, the only boring of any importance being the Letunofsky one, at Gorbunovka, near Poltava. The Tertiary and more recent beds here attain a thickness of over 670 feet, after which 231 feet of soft, white chalk was passed through. The bore was then discontinued, it being concluded that the Chalk might prove to be thicker than the deposit at Kharkoff.

While a good deal of work has been lately done with regard to the Tertiary deposits of the Poltava Government, no mention has been made of any exposures of the Cretaceous system in that part of the country.

We must go to the neighbourhood of the town of Kieff for conclusive evidence as to the presence of Cretaceous beds on the west of the Poltava Government. I am informed that a bore in the lower part of the town of Kieff passed through 30 feet of chalk, but have been unable to obtain the paper in which Prof. Theophilaktoff discusses this occurrence. This bed probably soon thins out and dies away at the great Archæan axis.

Further to the south (see map) along the course of the Dnieper, between Tripolie and Tcherkass, occur a series of beds of a glauconitic sandy nature, containing fossils of Cenomanian age, such as *Amm. Mantelli, Amm. varians, Exogyra conica*, and *Janira quinquecostata*. These beds are 80 feet thick, and have undergone considerable step faulting. The main dip is 30° S.W. that is, away from the river. [It would be of interest to know whether there is much trace of faulting along the course of the Dnieper, such as occurs along the Thames valley. Certainly the very high escarpment on the right side of the river, which forms such a picturesque object at the town of Kieff itself, might be due in some measure to such earth movements, just as there is a similar escarpment in the central portion of the course of the Donetz, and also on the Volga, the right bank being always the higher side.] The Cretaceous sands above-mentioned are surmounted by the Tertiary sandstones of Butschak and Traktemirov, whose fauna was already well known in Murchison's time. A little further down the river, at Krementchug, I observed gneisses well marked on the east side of the river, so that the Cretaceous deposits probably do not extend far south of their known outcrop as mentioned above. These beds rest upon Jurassic strata, with which they appear to be comformable.

3rd. In a direction S.E. from Kharkoff the Cretaceous beds have an enormous extension. Hidden under the Tertiary beds for a time, the Chalk reaches the surface in the neighbourhood of Izium. Here, as shown by Murchison, the Chalk is 80 feet thick; underneath these are greensand beds 70 feet thick, and then come 44 feet of Upper Jurassic beds. As this spot is 70 miles S.E. of Kharkoff, and no other Jurassic outcrop occurs between the two towns, it is probable that the Chalk slowly thickens towards the North.

Further to the S. a splendid display of the Upper Cretaceous and its subjacent beds occurs at the great monastery of Sviati Gori, in the fine escarpment overlooking the Donetz. The upper 300 feet consists of a somewhat coarse chalk, containing layers of flints. Below it occurs a large mass of somewhat fine greensand, which yielded no fossils to our research. It is well displayed in the winding road down to the river. I was unable to obtain sufficient evidence as to its exact thickness. It was certainly at least 15 to 20 feet. As will be seen, this greensand occupies an enormous area, and very probably belongs to the Pecten asper zone (Murchison).[1]

Variegated clays separate the greensands from the Jurassic limestones which form a second low cliff near the river. These beds are practically unfossiliferous, although strata of similar lithological character at Shilovka, near Simbirsk, yielded *Amm. consobrinus* to the researches of M. Jasikoff (see Murchison), and they may perhaps like them be referred to "couches supérieures Neocomiennes" of D'Orbigny.

Thus a comparison gives:

Kharkoff.	Izium.[2]	Sviati Gori.
Tertiary, 133 ft.		
Chalk and Chalk Marl. (1831 ft.)	Chalk. (30 ft.)	Whitish Chalk (about 300 ft.)
Green and grey sands.	Greensand (70 ft.)	Greensand (? more than 20 ft.)
Same alternating with dark clays.	....	Variegated clays.
	Jurassic Limestones.	Jurassic Limestones.

From Sviati Gori the Chalk area extends unbroken 20 miles to the south at Kramatorovka. The whole of the country between these two points consists of undulating steppe, the understratum of chalk being barely concealed by a thin covering of grass, whilst in every gully the chalk is seen to form the walls. In one of these the inevitable *Belemnitella mucronata* came to light.

---

[1] It may be noted that the repetition of the Jurassic Strata at Sviati Gori, at Kamenka, and at Tzium, is regarded by Prof. Gourov as being due to a succession of faults. It again raises the question how far parts of the courses of important rivers have been determined by such movements of the earth's crust. Prof. Gourov has shown the existence of Jurassic limestones not far from Poltava, so that it is probable that Upper Cretaceous beds do not extend far to the S. of that town.

[2] At Fedorovka, in the Izium district, a boring by Messrs. Winning, has shown the existence of 451 feet of variegated, green, and red clays, which probably belong to the same category as those mentioned above. At a bore between Barvenko and Stavrikov, in the valley between the stations of Gavrilovka and Slaviansk, the beds vary remarkably in their lithological character. For the first 50 feet variegated and brown clays predominate; the next 150 feet are sands and sandstones. For the next 100 feet there is contest between the clays, sandstones and limestones, the latter forming two or three bands 6 ft. thick, separated by wide intervals. The remaining 228 feet are almost entirely variegated brown clays. It is possible that these beds were deposited near a shore line, the sea, in which the Oolitic limestone of Sviati Gori was laid down, occasionally reinvading the district. Subsequently the clays themselves invaded the Jurassic sea, and covered the limestones, as at Sviati Gori.

It would seem as though the Cretaceous beds were sweeping round the Jurassic which bordered them on the W. side, and underlie them at Izium, Kamenka, and Sviati Gori. They then skirt the edge of the Permian district which contains the splendid Brianscoe and Stupki salt mines. Two points of interest here attracted attention, viz. that the alabaster hills stretching N. from Bachmut to Stupki were covered with flints, and that the Chalk forms a sharply marked escarpment stretching all along the left side of the railway from Kramatorovka to Vierolubovka. The conclusion seems irresistible, viz. that Chalk beds extended much farther to the S. over the Permian area, the flints being evidence of the past denudation and the escarpment evidence of that now proceeding.

Further to the E. the Upper Cretaceous actually overlaps the Carboniferous, and several coal-mines have been sunk through the Chalk to the Carboniferous deposits below. As Murchison had long ago remarked, the Chalk appears to occur in basins or pockets, filling up spaces between highly inclined Carboniferous strata. Thus he pointed out that an artesian well at Lugansk was made, 630 feet deep, Chalk being passed through all the time. At Uspensk again, white chalk occurs, containing *Inoc. Cuvieri*, *Lima semisulcata*, *Ostrea vesicularis*, and *Belemnitella mucronata*, and possessing bands of flints. The dip is N.N.E. He also mentions small tracts of Greensand to the N. of Lugansk, rising from beneath the Chalk, and loaded with *Exogyræ* and *Ostrea vesicularis*.

A remarkable case is presented by a boring recently carried out near Bielaia, close to the junction of the Cretaceous and the Carboniferous. About two-thirds of a mile from the station coal is being worked in true Carboniferous strata; at the station a bore has been constructed which passes through 600 feet of Chalk Marl, and below this through 200 feet of soft white chalk. At this point the bore was stopped, and no definite opinion as to the junction of the Cretaceous and Carboniferous can be stated.

Passing in the direction of Lugansk, to the E., some little distance along the railway, I noticed a very deep and well marked ravine. Not far removed from this ravine was an exposure of greensand. It appeared as though the great depth of Chalk at Bielaia might be due to faulting, the direction of the fault-plane being coincident with the ravine above-mentioned.

To the E. the Cretaceous passes under Tertiary beds, and not having been further in that direction, we must call attention to the work by Prof. Golovkinski, on the geology of the Taurida Government, as revealed by artesian borings.

Some 70 m. to the N. of Melitopol, on the Azoff Sea, a bore has been constructed at Oriechov, which shows the existence of the Cretaceous directly overlying the Archæan at that point. At Voskresenka, to the E. of this place, the Cretaceous ceases, and the remains of the Archæan axis separates it from the shores of the Sea of Azoff. This axis is not, however, complete to the N.W. a large strait of Miocene beds occupying the intervening space. The borings have shown that starting from a point 80 miles N. of Melitopol, the Tertiary beds attain their maximum thickness under the Azoff Sea, really forming an immense synclinal basin, bordered at one extreme by the Cretaceous and Archæan of the Don Cossack country, and on the other by the Cretaceous, the Jurassic, and Archæan of the Southern Crimea.

From the above data it will now be possible to form some more precise idea of the extent of the Central and South Russian Cretaceous Basin, and to trace its boundaries more sharply than has hitherto been possible. With that view I have visited many crucial points, and have made a study of various Russian writings either in the original or from references in other pamphlets.

(A map should be referred to in following out these conclusions:)

1. One boundary of the Cretaceous basin is very closely connected with the course of the Dnieper, the Chalk thinning out near Kieff, as shown by boring, the Cenomanian and Albien (as shown by Theophilaktoff) resting directly on Upper Jurassic W. of the Dnieper, therefore Cretaceous deposits cannot be of great extent, and must die away against the Archæan axis.

2. The Jurassic beds follow the line of the Archæan axis towards the S.E., the Cretaceous beds being thus limited to the N. The outcrop of these beds therefore bends sharply to the E. passing S. of Poltava, and resting directly (both Cenomanian and Senonio-Turonian) on the Upper Jurassic beds at Izium, Kamenka, and Sviati-Gori (Gourov and personal obs.) Borings also lead to the conclusion that the Jurassic beds are developed in the N. of the Ekaterinoslav Government to an extent not previously imagined.

3. The boundary then successively rests on Permian (near Bachmut) and on Carboniferous parallel to the S. bank of the River Donetz before it takes a bend to the E. From this point the Cretaceous expands in the Don Cossack country, sending off an arm, which, passing under the Tertiaries of Taurida, reappears in the Cretaceous hills of S. Crimea (Golovkinski). The main mass passes southward towards the Caucasus, disappearing under the Aralo-Caspian strata that occupy the space between the Azoff and Caspian Seas. Their boundary is probably somewhat N. of the main Caucasus range, as Neocomian fossils have been met with both at Kislovodsk and Piatigorsk.

It would be scarcely right to include in this paper the deposits containing *Inoc. Cripsii* and *Belem. mucronata,* which occur in the S. Caucasus and in Armenia and Daghestan, especially as these present the characters of the Southern Cretaceous type. With this limitation, the extension of the beds to the W. may be next studied, and in the provinces of Voronesh, Simbirsk, and Saratov, as also in the Obschei Sirt Hills, white chalk (apparently closely related to the Senonio-Turonian already mentioned) is developed on an immense scale. Murchison has shown that near Indovistye, W. of Voronesh, the W. chalk is only 20 feet thick and immediately overlaps the Devonian, 100 feet of Greensand (Cenomanian) occurring below.

150 m. to the E. at Volsk on the Volga the chalk is 200 feet thick containing *Belemnites?* possibly *Belemnitella*, *Pecten* (like *quinquecostata*). There is, however, a more general tendency for the Cretaceous beds to become clayey or sandy in the two Governments of Simbirsk and Saratov. The former condition prevails in the Simbirsk, the latter in the Saratov Government. Thus, at the town of Saratoff itself, Murchison had previously shown that the Upper Cretaceous beds, include white, grey, and bluish marls containing *Belemnitella mucronata* and *Pecten cretosus*. In the N. of the Simbirsk Government Neocomian and Aptien beds occur, and only the S. portion of the Government is occupied by the Upper Cretaceous. Finally, Sintzoff has shown that the Cretaceous is represented by soft Chalk and Chalk Marls in the Obschei Sirt, a band of hills in the neighbourhood of Orenburg. The white Chalk at Uralsk here contains *Belem. mucronata*, and *Echinocorys ovata*, thus probably forming the E. part of the great central basin. On the Siberian side of the R. Oural these beds sink beneath the Tertiary of the Kirghese steppes. It will be advisable to give the succession in a few typical localities in these Western Governments, so that a clear idea may be formed of their general characteristics.

The succession near Simbirsk (Yasikoff) is as follows (see Murchison).

I. (1) White Chalk, with courses of chert, occasional deposits of tripoli, and masses of ferruginous ochre. (2) Chalk Marl with bands of chloritic Chalk, in lower parts of which occur *Inoc. Cuvieri*, *Bel. mucronata*, and Zoophytes. (3) Marls with phosphatic nodules. Total above 250 feet.

In the Upper beds occur *Tereb. carnea*, *T. subrotunda*, *Micraster coranguinum*, *Plagiostoma Hoperi*, *Bel. mucronata*, *Scaphites æqualis*, with Zoophytes, Crustaceæ, and teeth and vertebræ of fishes.

II. Below these occur 300 feet of variegated clays, containing *Amm consobrinus* (Upper Neocomian). Their position reminds us of similar clays below Greensand at Sviati Gori.

III. The base is formed by the Besonov and Simbirsk clays, containing such typical forms as *Inoc. concentricus*, and *Hoplites Deshayesii*.

Lower down the Volga, at Kwalynsk, Chalk 200 feet thick occurs, resting directly on Jurassic sands and shales.

The characters of the strata at Volsk have been mentioned on the previous page.

Still following the Volga, we arrive at the town of Saratov, with the beds well exposed on its shores. There is here a lithological difference, and in Fig. 344 (Murchison's "Russia and the Urals") the succession is given as follows:—1. Grey clays with *Ostrea vesicularis*. 2. White, grey, and bluish marls with *Bel. mucronata* and *Pecten cretosus*. 3. Sponge-bearing strata. 4. Calcareous sandstones, with *Terebratula* and *Ostrea lateralis*. Below these come Jurassic beds.

100 miles to the S. at Kamischine, Inostranzoff mentions Neocomian and Aptien zones, whilst further S. at Bielaiaglina (white clays) pure white Chalk occurs containing *Terebratula carnea*.

We have thus followed Murchison in taking a typical series of localities on the Volga, the evidence showing that the Cretaceous, especially the Upper White Chalk, is strongly developed over a wide superficial area, though never apparently attaining any considerable thickness.

IV. Leaving the Volga district to the E. the boundary of the Senonio-Turonian basin passes to the N. of the Voronesh Government, to the N. of the Kursk Government and also through the N. of the Tchernigov Government, resting at Klintsi, on glauconitic ferruginous sands, sandstones and limestones, containing fossils of Cenomanian age. We have thus traced the great central basin (presumably Senonio-Turonian) from all evidence now to hand, showing its junction with the Cenomanian at points widely distant from one another, and the question now arises, How far can this basin be traced to the westward? At this point we must take advantage of the great Russian text-book, written by Professor Inostranseff, and the evidence he adduces proves that this basin is to be met with almost up to the Russo-German Frontier.

In Podolia and Volhynia white Chalk, Chalk Marl, and marly sands, are all met with.

In the main governments of Poland the same condition of things occurs, but here the Chalk Marl is rich in Turonian fossils, and there would appear to be more sharply defined limits between the Turonian and Senonian as we pass westward. In the Lublin Government (S. Poland) these beds are well developed, being 300 to 540 feet thick, and resting directly on glauconitic sands or marls containing Gault fossils.

The Upper Cretaceous has also a wide extension in the N. of the Government of Grodno, as also in Kovno and Courland, and there seems no reason to doubt that the great Russian Upper Cretaceous area is thus directly united with the Swedish deposit, and is only hidden by a thick series of Tertiary beds.

CONCLUSIONS AS TO CENTRAL AND RUSSIAN UPPER CRETACEOUS BASIN (EXCLUSIVE OF CENOMANIAN).

1. Its length from E. to W. is almost equal to the greatest breadth of the Russian Empire (over 1200 miles). This is reckoned from the River Vistula, near Lublin, to the River Oural, near Orenbourg.

2. Its general breadth may be taken at 200 miles from N. to S. Thus from Kursk to Tzium this breadth is attained.

3. Its greatest known depth is attained at the town of Kharkoff (1831 feet), thus presenting the greatest thickness of Chalk and Chalk Marl in Europe. This diminishes towards Poland, on the W., where it is 540 feet thick, and toward the Volga, on the E., where it is 200 feet thick.

4. Its palæontological contents show it to represent a facies which is not definitely Senonian or Turonian, but is a combination of both (Senonio-Turonian), and that the lithological variations (Chalk and Chalk Marl) have no effect on the character of the enclosed fossils.

Apparently, however, towards the W. the W. European conditions seem to be more nearly approached. No zones can be determined.

5. That the White Chalk and Chalk Marl have no absolute definite relation to each other (White Chalk being sometimes found both below and above Chalk Marl), but that in general the former overlies the latter.

6. That the Upper Cretaceous is unconformable to the Tertiary overlying it, and on its S. border rests successively on Archæan, Jurassic, Permian, Carboniferous, and Archæan.

7. That a great part of these deposits is overlain by Tertiary and Post-Tertiary deposits. (An important Phosphatic deposit occurs a few feet above the junction of the Tertiary and Cretaceous, extending through the Kharkoff, Poltava, and part of the Kieff and Kursk Governments.

8. That the Upper Cretaceous does not form one single synclinal basin, but is folded into several anticlinals and synclinals, which are then unconformably overlain by the Tertiary.

The above, then, are the main general points with regard to the Senonio-Turonian basin of S. Russia.

For the Cenomanian the following conclusions may be enunciated:

1. That in the largest number of cases where junction exposures are shown, it is found underlying the above-mentioned beds.

2. That borings prove it to underlie the Chalk and Chalk Marl at the points of their greatest depth (as at Kharkoff).

3. That lithologically it is mainly Greensand, and is on the average about 100 feet thick.

Of late years, however, new problems have come into the field, and new paths have been opened up. The "Challenger" expedition has thrown new light on the Ocean deposits of the present day, and once more interest is turning to that vast Chalk area which lies at our very doors. The homogeneity of the Chalk is fast becoming a myth of the past, and the microscope seems likely to help in unravelling something of the physical geography of that far distant period.

Hitherto, however, if we mistake not, the efforts in this direction have never been undertaken on a large scale, unless, perhaps, exception be made in the case of M. Cayeux's researches on the Senonian and Turonian of the Nord. The attack has in other cases been mainly made on Chalk containing more or less phosphatic material. The problems may be discussed perhaps a little as follows:

1. What are the actual residues left after solution of the calcareous portion of the Chalk?

2. How far may those fragments reveal their own origin, and so throw light on the causes which brought them into their present position?

The researches of M. Cayeux on the Dièves of Liege (Soc. Géol. du Nord. Annales, vol. xix. 1891, 2^e Livr), may well serve as a basis for further experiment in this direction.

Statements, however, as to the contents of the Chalk residues in the Tchernigov Governments are to be met with in Professor

Armachevsky's paper on this district. He shows that the dried white soft Chalk is composed as follows:

CaO	55·46	The residue is clay and some quartz grains. These may sometimes form 1 per cent. of the whole, giving rise to a harder white limestone.
MgO	·12	
CO_2	43·70	
Residue	·41	
	99·69 per cent.	

Glauconitic Chalk also occurs in a few places, as at Rogovka; an analysis is as follows:

Mainly Coccolites and Foraminifera	CaO	36·57	*Residue* = angular grains of quartz (0·03 0·1 mm. diameter), about equal diameter, transparent. *Glauconite* = olive-green, and some evidently casts of *Textularia*, *Rotalia*, and *Nodosaria*. Also plates of Mica and clayey parts.
	MgO	Traces	
	Co_2	28·78	
	Residue	34·63	
	(acetic acid)	99·98 per cent.	

The presence of mica (muscovite), both in this Chalk and in the Chalk Marl to be mentioned below, is of special interest, as some of the Archæan rocks, about 100 miles distant, are very rich in this mineral, muscovite-granites with garnets being not uncommon.

The Chalk Marl differs but little from the above except in the large amount of residue it contains:

CaO	22·05—22·34	Composition of residue as above.
MgO	Traces	
CO_2	17·32—17·55	
Residue	60·00—61·14	

Had we been aware at the time of the interesting problems now opening up, we should have made a far greater collection of specimens of Chalk and Chalk Marl than is at present at our disposal, but Messrs. Winning have agreed to preserve specimens of the varieties of Chalk they may henceforth obtain from their borings, and if they should carry out their promise, great hopes may be entertained of considerably advancing our knowledge on these subjects.

As it is, we have brought with us examples of the Bielgorod soft White Chalk, the Kharkoff ditto (500 ft. from surface) Chalk Marl from Bielaia (800 feet down) and Chalk from Sviati Gori. Also a few specimens from the Kharkoff bore, which have not been labelled as to depth. These may serve as types, but will not be sufficient for the establishment of any broad generalization.

II.—DID THE MAMMOTH LIVE BEFORE, DURING, OR AFTER THE DEPOSITION OF THE DRIFT.

By Sir HENRY H. HOWORTH, K.C.S.I., M.P., F.G.S., etc.

(*Continued from page* 258, Vol. IX. June, 1892.)

HAVING sifted the evidence in so far as it is available in Scotland and the North of England, we will now advance further south; and first in regard to the Eastern Counties. Here as elsewhere it is unfortunate that we so very seldom can find the beds upon which the solution of the problem depends in actual contact so as to apply the only real test, namely, that of superposition. When we can do so, it seems to me the case is conclusive.

In Mr. Jukes-Browne's Survey Memoir on the eastern part of the county of Lincolnshire, there is only one section given in which the Pleistocene Mammals occur, namely, at Burgh. Here remains of *E. antiquus*, *R. leptorhinus* and *Bos primigenius*, or of Bison, were found in gravel *underlying* 3 to 6 feet of Boulder-clay and underlaid by a black turfy bed and by marl (*op. cit.* p. 86).

At Little Bytham, in the same county, Mr. Skertchly found *Corbicula fluminalis*, which marks the same horizon, under Boulder-clay.

We will now turn to East Anglia. Recent discoveries have tended to increase, rather than to solve, the difficulty of fixing the exact age of the Forest Bed. The discovery of remains of the Musk Sheep, of the Hyæna, the Glutton, all animals characteristic of Pleistocene times, seems to suggest either that the Forest Bed has been hitherto ante-dated; or that, like the Norwich Crag, it may consist of re-arranged or *remainé* materials. Whatever view may be adopted, there can be little doubt now that the Mammoth occurs in the Forest Bed. Dr. Leith Adams, writing in 1881, describes several molars found in it by Mr. Savin, which he unhesitatingly identifies as Mammoth, and he adds: "I can have no hesitation in admitting the Mammoth among the pre-Glacial mammals of the British Isles" (Pal. Mem. p. 174).

This last clause is no doubt a deduction from the fact that the Forest Bed, as exposed at Cromer, underlies the whole of the Drift deposits.

Mr. Austen, writing in the 7th volume of the Q.J.G.S., speaks of the beds of terrestrial origin, *i.e.* of the land surface exposed at Runton and Mundesley, and says the Mammalian remains found *in the overlying Till* have in every instance been derived from portions of the expanse of that former terrestrial surface (*op. cit.* p. 133).

Again, Professor Dawkins tells me one of Mr. Gunn's Elephant teeth from the Norfolk coast was striated and rubbed as if by glacial action.

It is in Suffolk, however, not in Norfolk, that the most interesting and critical test case is supposed to have been forthcoming, namely, the classical section at Hoxne first described by Prof. Prestwich in 1859, and which, for a long time, was accepted as conclusive, and is still the basis of the orthodox geological opinion about the age of palæolithic man. It seems to me that the conclusions based upon this particular instance will have to be surrendered. In the first place the sections given by Prof. Prestwich are most uncertain in their reading. Thus in the first and most important section *no bed of Boulder-clay is given at all.* In the section of the pit in which flint implements and Mammalian remains were actually found, *all the beds* contain fresh-water shells or peat, or Mammalian bones, and there is no trace of drift at all (see Phil. Trans. vol. 150, p. 305).

Feet.		
1 to 2	*a.*	Surface soil, traces of sand and gravel.
10 to 12	*b.*	Brown and greyish clay, not calcareous, used for brick-earth, with an irregular central carbonaceous or peaty seam. Two flint implements found in this seam the previous winter.
½ to 1	*c.*	Yellow rectangular flint gravel with some chalk pebbles and pebbles of siliceous sandstone quartz, and other older rocks. Bones of Mammalia.
3 to 4	*d.*	Bluish and grey calcareous clay in places very peaty, with wood and vegetable remains, land and fresh-water shells. Bones of Mammalia.
1 to 1½	*e.*	Gravel like *c*, but smaller and more worn, with more chalk pebbles.
	f.	Calcareous grey clay more or less peaty, with fresh-water shells. Mr. Prestwich says he made a boring in this clay 17 feet deep without reaching bottom.

It is true that Mr. Prestwich and Sir J. Evans had some trenches dug in other parts of the field which showed the white and ochreous sands and gravels to be underlaid by a grey clay, but I altogether demur to treating this clay as boulder-clay. It seems to me to answer to the clay marked *f* in the big section in the pit. At a distance of 150 yards from this pit is another pit where Boulder-clay is dug, and here we are expressly told that no other beds were exposed (*id.* p. 307). Mr. Prestwich himself calls attention to the unsatisfactory character of the evidence (*id.*). The Boulder-clay caps all the hills aronnd. Its very uneven base rests on white and yellow sands and gravel.

In 1876 Mr. Belt wrote an elaborate paper in the Quarterly Journal of Science, giving many sections of the ground at Hoxne, in which he sharply contested Professor Prestwich's conclusions, and avowed his opinion that the facts prove the implement-bearing gravel there to underlie and not overlie the Boulder-clay.

Lastly, let me quote my friend Mr. H. B. Woodward. In a paper read before the Norwich Geol Soc. he says: Mr. Belt recorded traces of Chalky Boulder-clay on the Hoxne beds, and my colleague Mr. Reid *and myself subsequently observed two tiny traces of this Boulder-clay on the brick-earth in the pit in the park* (Proc. Norwich Geol. Soc. pt. ii. p. 62). It having been suggested that these pockets of Boulder-clay were brought into their position by man, Mr. Reid writes "they seemed to have been there for a long while, for they were grassed over, and, if I remember rightly, an oak tree was growing on one of them (Mems. Geol. Surv. 50 N.S. p. 30).

It is clear therefore that when analyzed, the case so often quoted, and upon which such a stupendous induction has been based, utterly breaks down, and that the evidence there, if it points a moral at all, points to the actual reverse of the one maintained by so many geologists.

Let us, however, proceed further, and in the first place turn to another district in Suffolk, namely, the neighbourhood of Brandon.

Mr. Skertchly affirms positively, in one of the volumes of the Mems. of the Geol. Survey, that Early Palæolithic remains are found there in a series of loams, sands, and gravels *overlaid by chalky Boulder-clay.* "To this series," he says, "I have given the name of the Brandon beds. They are very fragmentary, but seem to occur pretty nearly all over East Anglia wherever the chalky

Boulder-clay extends, always cropping out at or close to its base, and never in a single instance occurring away from it. This remarkable association is only explicable on the supposition that the Brandon beds are older than the chalky Boulder-clay, and indeed that clay can be actually seen lying thick upon them, and often contorting them, sometimes for a mile at a stretch. Up to the present time they have yielded implements or flakes at Botany Bay (near Brandon), Mildenhall brickyard, High Lodge, Mildenhall, Bury St. Edmunds, West Stow, and Culford. The first discovery was at Botany Bay, and at the time no Boulder-clay was visible at the precise spot, but it has since been met with, and I had the pleasure of the experience of Mr. Amund Helland when this fact was made clear. At Mildenhall brickyard and High Lodge good thick chalky Boulder-clay overlies the Brandon beds, whence many implements have been obtained, and at Culford, whence I dug out a good flake, in company with Mr. F. J. Bennett, the Brandon beds are worked under 15 feet of chalky Boulder-clay, and can be traced beneath that deposit for the distance of a mile to the eastward" (Age of Palæolithic Man, pp. 67–69).

I ought to say that on a copy of this Memoir in the Jermyn Street Museum there is, in the handwriting of Professor Ramsay, the following note attached to a section: "Pit beneath Boulder-clay, opened for some years, and dug into again in 1878, where the flint implements were found, sent to the Museum by Mr. J. C. Maynard of Brandon" (*id.* p. 68).

In regard to the beds at Mildenhall, where Mr. Skertchly found his Palæolithic implements, Mr. H. B. Woodward, who has examined the locality carefully, says: "There was brick-earth overlaid by Boulder-clay. . . . . . There was no escape from the conclusion that the brick-earth was older than the Boulder-clay. This bed of brick-earth, and other beds of brick-earth near Thetford, interested me much, for I had come across similar beds near Norwich, which were older than the Boulder-clay. Sir A. C. Ramsay, Mr. Bristow, Mr. Whitaker, and others, have now seen the sections described by Mr. Skertchly, and have agreed with him that the brick-earth, said to contain Palæolithic implements, is older than the Boulder-clay" (Proceedings Geologists Association, vol. ix. number i.).

Speaking of the gravels at Ipswich in which Mammalian remains have occurred, Mr. Whitaker refers to the difficulty of classifying the gravel and in dividing it from the like deposit of glacial age *against which it ends off.* He also speaks of the Boulder-clay having been *found at the surface* in the town itself (Geology of Ipswich, etc., p. 93).

Elsewhere he writes of finding pieces of bone or of Elephant's tusk, with shells, in a low cliff of buff sand and loam lying directly on London Clay (*id.* p. 95).

The horizon of the famous Mammalian deposit at Barrington in Cambridgeshire has been much discussed and it has been very dogmatically stated on more than one occasion that the beds are post-Glacial, meaning posterior to the deposition of the drifts. I cannot see any evidence in this. The sections clearly show that the bone beds are overlain by trail as Mr. Irving himself admits (Q.J.G.S. vol. xxxv. p. 670), and they rest on the Greensand and Chalk-marl.

In the adjoining County of Bedford I know of no direct evidence of super-position, but inasmuch as a great deal has been made of such evidence as is there forthcoming by the advocates of the so-called post-Glacial date of the Mammoth and Palæolithic Man, it may be well to devote a few words to them and especially to the section at Biddenham.

Mr. Prestwich has given an admirable section of the deposits in the valley of the Ouse at this point (Q.J.G.S. vol. xvii. p. 364). From this section it seems that the valley of the Ouse has been scooped out of the Oolitic rocks known as Cornbrash. In the lowest portion of the trough so created runs the river Ouse, which has deposited a certain amount of alluvium along its course. On a higher level in the valley is the bed of gravel in which the flint implements were found. Lastly, the bounding heights of the valley on each side are capped with Boulder-clay, which stretches for miles in all directions (Lyell, *op. cit.*). The theory generally adopted is that the Boulder-clay was once continuous across the valley, and that the valley has been scooped out of it. This is the view of Mr. Prestwich, Sir J. Evans, Sir Charles Lyell, etc., etc.

One thing is clear, if the Boulder-clay once occupied the valley in this way the scooping out must have been most complete, and the floor of the valley laid bare; for as Sir Charles Lyell expressly tells us the two implements first found in the gravel were found "at the depth of 13 feet from the surface and rested immediately on solid beds of Oolitic limestone," and so he reprints it in his section. At this point, then, the evidence is plain that there is no superposition of the flint-bearing beds on the Glacial clay. The former lie directly on the floor of the valley, and such evidence as is forthcoming at this point is of an essentially secondary and deductive character and certainly does not warrant the assertion of Sir Charles Lyell, that the Bedford sections teach us that the fabricators of the antique tools and the extinct Mammalia coeval with them were post-Glacial (*id.* p. 217). But let us proceed somewhat further. In 1866 Mr. Flower described the discovery of flint implements, at Thetford, on the Ouse. These he tells us were obtained from 12 to 15 feet below the surface *and within a foot or less of the Chalk on which the gravel rests*; *and some were found in some gravel filling potholes in the Chalk* (Quart. Journ. Geol. Soc. vol. xxii. p. 567). Here the evidence carries our case still further, for not only does the gravel lie immediately on the solid rock, but also in the potholes; so that the sweeping out of the Boulder-clay must have indeed been complete and profound. Let us turn to another site in the same valley, namely, at Summerhouse Hill, where Mr. Wyatt found flint implements which had come from beds containing a similar assortment of Mammalian bones and land and freshwater shells to those found nearer Bedford. He gives an admirable section across the valley at this point showing a state of things precisely the same as in the sites already referred to (Quart. Journ. Geol. Soc. vol. xx. p. 185).

The Boulder-clay caps the ridges of Navesden and Hammer Hill, bounding the valley on either side; but within the valley itself, including the elevation of Summerhouse Hill, there is no glacial deposit. That Hill divides the valley into two troughs, in each of which the drift gravels with Mammalian bones and shells are found, and in each these gravels repose on the Oxford Clay and that on the Limestone of the Middle Oolite.

I am further bound to say that in Mr. Wyatt's section, published in the Geologist for 1861, page 243, and again by Mr. Prestwich in the Q.J.G.S. vol. xvii. p. 364, the Mammal and Implement bed at Biddenham appears to be overlain by drift.

Turning from Bedfordshire the only discovery of interest in Central England in the present discussion was made in Hertfordshire.

Professor Prestwich, writing in 1858, says: "A ballast pit has recently been opened at the Watford end of the Bricket Wood cutting, and immediately south of the line, which exposes a section of much interest. The Boulder-clay has there almost thinned out, leaving but a seam one or two feet thick, whilst above and below it is a thick bed of gravel. . . . The lower gravel I believe to pass under the Boulder-clay. . . . In the ballast pit I was fortunate enough to discover in the lower gravel a few pieces of the tooth and tusk of the Elephant. . . . The lower gravel reposes upon an irregular surface of chalk (Geologist, 1858, p. 242).

Let us now turn to the Welsh caves.

Dr. Buckland says that in 1836 he found, on the property of Mr. Lloyd near Cefn Cave, fragments of marine shells associated with the usual detritus, and inferred from the fact of Mr. Trimmer and Dr. Scouler having discovered recent marine shells and drifted pebbles over the bones in the cave, and from the admixture of the bones of mammifers with diluvium in Kirkdale, Torquay, and other caverns, either that these caves were submerged subsequently to their having been inhabited and again raised above the level of the sea, or that vast irruptions of water, apparently loaded with icebergs, had overwhelmed the country (Proc. Geol. Soc. vol iii. p. 584).

Making allowance for the geological language which then prevailed, this means that so far back as 1836 Dr. Buckland had affirmed that the Mammalian bed in the Cefn Cave was overlain by drift.

Mr. D. Mackintosh, in speaking of the Cefn and Pont Newydd Caves, refers to the clay in the cavern as containing angular and subangular fragments of limestone, a few polished fragments and pebbles of limestone, and a few pebbles of Denbighshire sandstone and grit, felstone, etc., and he says: "It is horizontally continuous with the Upper Boulder-clay of the district. The clay, he says, can be traced along the plain of Lancashire and Cheshire, the coast of Flintshire, and up the Vale of Clwyd. It spreads over the gently rising ground between St. Asaph and the Cefn and Pont Newydd Caves, and it may be seen all round the caves, in some places filling up hollows, in others covering plateaux, and in not a few instances clinging to the face of steep slopes, or even adhering to narrow rock terraces or ledges. I have been familiar with this clay in Cheshire and Flintshire for four years, and have therefore little hesitation in asserting that traces of it, in an unmodified state, may be found at the entrances of both the Pont Newydd and Cefn Caves, that in the interior of the Cefn Cave, for a considerable distance from the entrance, there are indications of this clay once having filled the cave nearly, if not quite, to the roof, that in the interior of the Pont Newydd Cave it maintains its unmodified character for a considerable distance from the entrance, and that in no part of these two cases has this clay been modified further than what may have resulted from the dropping of calcareous matter, from the temporary pounding back of water in the recesses or hollows, or from accumulations within the caves under conditions which may have differed from those without" (Q.J.G.S. vol. xxxii. p. 92).

Let us now turn to another case.

The Cae-Gwyn Cave has acquired a great notoriety in this controversy. The evidence it furnishes seems to me to be clear and conclusive, that the Palæolithic remains were there overlain by glacial deposits at 135 feet from the entrance. As early as 1885, sand, like true marine sand, was found overlying the Bone-bed and laminated clays. This sand was examined in that year by Professor Dawkins, who says, "I have carefully compared the sand and gravel found in the upper cave Cae-Gwyn and mud sometimes adhering to the bones with the glacial sand and gravel which occurs in the valley a little way above, and find that in every particular they agree. I have also compared them with the glacial sands and gravels near St. Asaph and find that all three are composed in the main of quartz, quartzites, and Silurian fragments" (Q.J.G.S. vol. xliv. p. 562).

In 1886 further excavations took place, and a section was exposed in which the bone earth was found to be overlain by laminated clay, sand, and gravel, this again by clay with boulders and bands of sand and gravel and this by soil (*id.* p. 563). The various sediments in the cavern, says Dr. Hicks, retained their relative sequence throughout and this sequence was continued uninterruptedly from the cavern into the drift section on the outside (*id.* p. 566).

In this reading of the evidence, Sir A. Geikie, Mr. De Rance, Mr. Tiddeman and Mr. C. Reid concurred. Mr. Morton says: In June last during the progress of the excavation in front of the original entrance to the Cae-Gwyn Cave I stayed at the inn close by for eleven days. From the first time I saw the section I felt convinced that all the beds were strictly *in situ* . . . The laminated clay had evidently been tranquilly deposited over it (the bone earth), the sand and gravel were over the laminated clay, but current-bedded as such so-called 'Middle sands' often are. Finally, the Boulder-clay occurred over the sand and gravel without any evidence of disturbance or rearrangement whatever. . . . The Boulder-clay appeared to me as good an example of undisturbed clay as anywhere in the Vale of Clwyd, Cheshire, or Lancashire, while the Erratics are very similar . . . if it were to be considered post-Glacial we should have no Glacial deposits in the district . . . the remains of Mammalia found in the bone-earth were evidently deposited in the cave before the deposition of the Boulder-clay, and there are no indications of any interglacial period between it and a still earlier period of land glaciation (*id.* pp. 571–2). Dr. Hicks says, "The recent researches at Cae-Gwyn have proved most conclusively that there was no foundation for the views of those who contended that the drift which crossed over the entrance and extended into the cavern was remainé and had gradually crept down the hill. They have shown beyond the possibility of doubt that the deposits which overlie the true earth are *in situ* and are identical with the typical Glacial deposits of the area. . . . The excavations carried on in 1885, 1886 and 1887, show that the caves must have been occupied by the animals before any of the Glacial deposits now found there had accumulated (*id.* p. 575). Mr. De Rance writes, June, 1886, "the entrance to the cavern had been discovered and a vertical shaft 20 feet deep, disclosed Boulder-clay resting on drift sand which passed continuously into the cavern itself, while the underlying bone-earth similarly passed outside the cavern and formed the base of the cutting as far as it was carried. In June, 1887, the pit in the drift was cut still further back, the bone-earth still continuing to form the base of the Glacial drift" (*id.* p. 576). "Mr. Strahan believed that the drift of the mouth of the cave was part of the northern drift which he had mapped over a large part of Denbighshire, Flintshire and Cheshire, and that the bone-earth lay beneath it" (*id.* p. 577).

In the discussion on Prof. Hughes' paper in the Q.J.G.S. vol. xliii. on the drifts of the Vale of Clwyd, Dr. Hicks said the Arenig drift is known from well-sinkings to be underlain by sands and gravels like those at Talargoch, in which bones of animals, similar to those found in the caverns, have been discovered. He said further, that he was perfectly convinced by the evidence found during the exploration of the caves of Ffynnon Beuno and Cae-Gwyn that they must have been occupied by man and the animals before the climax of the Ice-age, and that the mammalian remains and the implements must be considered as of pre-Glacial age. Professor Dawkins said that after examining the first section he felt obliged to accept Dr. Hicks' evidence. The drift above the place where the implements was found was, in his opinion, not *remainé* but *in situ*; with regard to the mammalia found in the caves of the Vale of Clwyd, nearly all were living in the eastern counties in the pre-Glacial age" (*op. cit.* pp. 116–118).

Prof. Prestwich, in 1887, in abandoning his earlier view, which was against the existence of pre-Glacial Man, said that the cave work of Mr. Tiddeman and Dr. Hicks gives strong presumptive evidence of the earlier geological appearance of Man in the British area; and he saw no reason to doubt the sub-Boulder-clay evidence of Mr. Skertchly. Of the correctness of his opinion in regard to the stratigraphical position of the bed in which his specimen was found, I have, however, little doubt (Q.J.G.S. vol. xliii. p. 406–7). In the discussion which followed, Mr. De Rance said he quite agreed with Dr. Hicks in his interpretation of the facts observed by him (*id.* 409).

In the *Hyæna-den, near Ross,* situated 300 feet above the present

Wye, Mr. Symonds found a stratified red sand and silt, 3 or 4 feet thick, containing pebbles, one of which was greenstone; and he adds: "Every one of those pebbles out of that red sandy deposit must have been derived from Silurian and Trap rocks which are not to be found *in situ* until after we have traversed the long tract of Old Red Sandstone through which the Wye passes between Coppel Wood Hill, near Ross and Trewerne, above Hay or Breconshire, a distance, by the river of 70 or 80 miles" (Geol. Mag. Vol. VIII. p. 436).

The evidence of this cavern therefore completely supports that from North Wales.

If we now leave the area where true Glacial drift is supposed to occur and enter the Thames Valley, the evidence seems to me to be equally conclusive.

In the Thames Valley Boulder-clay is not found, but I suppose it is generally agreed now that the Trail of Mr. Fisher represents it. Now, there can be no doubt that this Trail overlies the Mammalian and Palæolithic gravels of the Thames Valley.

Dr. Falconer, in discussing, in 1857, the deposits at Gray's Thurrock, and the lower beds at Brentford, in the Thames Valley, "inferred that they were of an earlier age than any part of the Boulder-clay or Till" (Q.J.G.S., vol. xiv. p. 83). "It appears," says Mr. Symonds, "that these Thames brick-earths are covered by a Glacial deposit of ice-borne *débris*, as is the Forest Bed by Boulder-clay" (Geol. Mag. Vol. V. p. 420).

Professor Boyd Dawkins, in his paper on the age of the Lower Brick-earths of the Thames Valley in 1867, gives a section from the Uphill Pit at Ilford, in which the famous head of the Mammoth now in the British Museum was found. The bed in which it occurred was covered by several beds of loam, clay, gravel, and sand, of one of which Professor Dawkins says: "By the comparison of its bedding, the admixture of clay with sand and gravel, and the presence of pebbles of chalk and of large transported boulders of grey weathers and of flint, is proved beyond doubt to be of Glacial origin—to have been carried down by the ice and deposited on its melting, upon the eroded top of the fluvatile deposits below." In regard to Mr. Prestwich's notion that the bed was partially formed from gravel derived from the Boulder-clay, Mr. Dawkins says, "a careful examination compels me to believe that there is no proof of the derivation of this Glacial deposit from the wreck of the Boulder-clay" (Q.J.G.S., vol. xxiii. p. 93). Turning to Gray's Thurrock, he argues that we have precisely the same superposition, there being bed numbered 6 on the section which from the irregular size of its pebbles, its tabular flints, its contortions, and its irregular deposition, owes its presence to ice in some form or other. Its sandy nature may be owing to the Thanet sand having been caught up by the ice and deposited on its melting, just as the clayey nature of the Trail at Ilford was probably owing to portions of the London Clay being in like manner transported (*id.* p. 95). This bed was distinctly superimposed on the gravel containing Mammalian bones. At Crayford he gives a section in which a similar bed, number 7, consisting of an irregular reddish-sandy contorted stratum, full of large flints both angular and water-worn, and of quartz pebbles, and confusedly bedded, is found in just the same situation as the drift beds above named (*id.* p. 96). At Erith, Mr. Dawkins discusses an interesting section, in which he found the same superposition; and he specially remarks upon the presence of a large block of black clay, with its angular shape preserved, which had been transported about 150 yards and deposited in the Trail, and says of it: "It is altogether impossible that this angular mass of clay could be transported more than 150 yards, preserving its angularity, and deposited in such a matrix, by any other agency than that of ice. The tract here was highly contorted, contrasting much with the horizontal beds below it" (*id.* p. 98). He concludes that the beds at the several points described are contemporary, and that they establish that after the temperate conditions marked by the Mammalian remains, they were followed by a period of intense cold, in which stones, sand, clay, and indeed whatever came within the reach of the ice in the neighbourhood, was caught up and deposited in a most confused jumble on its melting (*id.* p. 99); and in summing up the case he puts the Lower Brick-earths of the Thames Valley distinctly below the Glacial beds (*id.* p. 109).

In discussing Mr. Dawkins's results, Mr. Marr, in the GEOLOGICAL MAGAZINE, suggests that the beds of the Thames Valley containing transported materials may be an inland extension of the Boulder-clay *on the same level* (*op. cit.* vol. iv. p. 100).

Lastly, we have the most recent discovery of all, so lately discussed before the Geological Society by Dr. Hicks, where an old land surface containing considerable unweathered remains of the Mammoth was found in the heart of London reposing directly on the London clay, overlain by a clay containing drift from Hertfordshire, and filled with chalk, which Dr. Hicks, as I think, most conclusively correlates with the chalky Boulder-clay.

I have now examined every instance known to me where it is possible to test by superposition the question of the relative age of the Mammoth beds and the Drift in the British Isles, and I claim to have shown that, as tested by these islands, the Mammoth beds are in every instance overlain by the Drift, and are never underlaid by it. I propose in another paper to consider how far this conclusion is supported by the evidence from foreign countries.

III.—ON RAPID ELEVATION OF SUBMERGED LANDS AND THE POSSIBLE RESULTS.

By Rev. E. HILL.
Late Fellow and Tutor of St. John's College, Cambridge.

IT is not impossible that readers of a paper lately published by our venerated senior geologist may have been startled, some for one reason others for another and opposite. On reading the suggestions he has put forward as to the results from rapid elevations over southern England, some will recoil as at a revival of catastrophic *machinery; some* on the other hand may hail the invention of a novel and most potent agency. I doubt whether either view is altogether correct or defensible.

In the paper referred to (Q J.G.S. vol. xlviii. p. 332) there is quoted a discussion by Mr. Hopkins on the results from "paroxysmal elevations" of areas at the bottom of the sea. The writer, however, says that he himself is contemplating "not such great changes and powerful [resulting] currents," but still, movements of this character in which "the uplift was rapid." "It is evident," he says, "that we have in this form of disturbance an engine of enormous power." The phenomena called the 'Rubble Drift' of southern England, he suggests, may have been produced by currents of water pouring off from areas "rapidly uplifted." The areas uplifted are to be variable and uneven land-surfaces. The amounts, however, of uplift are not indicated clearly, and the degrees of rapidity not at all. What amounts of elevation are contemplated, and what rates would be regarded as 'rapid'?

Darwin records sudden elevations in Chili to the extent of ten feet (Nat. Voyage, chap. xiv.). Lyell mentions a subsidence reaching forty feet; but the area was small, and subsidence is a much simpler matter than elevation. I think that twenty feet may be regarded as a considerable height through which to 'rapidly' raise even a few counties along the coast. 'Rapidly' it must be remembered is a relative word. Light is rapid compared with sound; its velocity being nearly a million times as great. A cannon ball is also rapid compared with a snail: if a snail's pace be an inch per minute the one is also about a million times the other. But the rates of elevation, so far as I know them, which have been measured in Scandinavia and elsewhere are such that to change them into the pace of such a snail would be a greater multiplication of speed than that required to make the snail gallop alongside the cannon ball. In an old jesting problem of our childhood, a snail was set to climb twenty feet of wall at the rate of two feet per day. Accelerate his pace so that in six hours only he can climb the whole twenty feet; to increase his pace into that of a cannon ball would require no greater change than the increase that would lift Scandinavia through twenty feet in six hours. Would not this be a 'paroxysmal' change?

Again, the force required to produce such elevation would be prodigious. We know, indeed, little of the forces at work under the earth's crust, but is any force we are acquainted with able to produce a perceptible fraction of such a result? Most violent Japanese earthquakes exhaust their potency in vibrations measured by inches or by less. What must be the violence which could permanently uplift a country several feet! Mr. Whymper saw Cotopaxi eject a mass of ash which he calculates at two million tons or more. This enormous mass was shot up to a height of 20,000 feet in a single minute.[1] But the work so done would not suffice to uplift the mere surface soil of an English county through a single yard. Suppose that the power which did this prodigious work within one minute, instead of exhausting itself in that minute should continue with unabated violence for six long hours. In those six hours it could have uplifted a mass of rock, in depth a mile, under the surface of an English county, through less than a couple of inches. The multiplications to obtain an adequate force are not quite so immense as those required for the rate, but might suffice to make a mouse as strong as an elephant. Besides, here we are making comparison with paroxysms. The mouse is itself a mountain in labour. Cotopaxi in eruption must be magnified by a power of ten thousand.

---

[1] Travels among the Great Andes of the Equator, p. 328. I am not sure whether he means that the whole operation was completed in a minute. If not, the force in action was less than I am assuming it to have been.

No such force then would be capable of uplifting southern England through several feet even in a long summer's day. Accordingly, we seem justified in regarding an elevation of twenty feet within six hours as an elevation effected with very great rapidity according to any reasonable use of the word. Most, indeed, would regard such action as paroxysmal and catastrophic. But, whether so or no, there is not the slightest doubt that the effects produced by the water as poured off from the land so elevated would not be catastrophic. Such effects are not rare but common. They are matters of daily experience. More even than that, they may be seen produced, over a large area, on a large scale, twice in every day. Twice in every day for hundreds of miles along our coasts the level of the land compared with the sea rises some twenty feet or more in six hours, and twice in every day it again falls, through the same space and in the same time. True, this is due to alterations in the sea level, not in the land, but *as far as regards the flow of waters off from or on to the land* the effects must be precisely the same. The action of waters pouring away from a rising land can be seen, can be studied, can almost be experimented upon, twice daily in the Tides.

The tides along most of our southern and western coasts give us the results of elevations up to twenty feet or more. In Jersey we can examine elevations up to thirty feet; at Chepstow up to forty; those who can travel as far as the Bay of Fundy will perhaps be able to see what seventy feet could do. Thus, on the one hand, the effects of the supposed exceptional agency would not be exceptional, but common ordinary effects; and on the other hand, it does not seem necessary to invoke such exceptional agency; for if the effects be produced by it, then the daily work of the tides is capable of producing daily the same sort of effects. "In the case [considered in the paper] the area of elevation consisted of a variable and uneven land surface," such a surface as is alternately covered and exposed in the archipelago of the Channel Islands. "Each hill or group of hills formed a centre for the diverging currents," as in that archipelago each islet, shoal, or group of rocks, for the ebb and flow of the tide. "The velocity of [these currents] would further vary according to the varying gradients and lengths of the slopes," but much more according to the conformations of the subaqueous channels. "Where the sediment is fine we may conclude that the velocity was slow, and the rise which gave origin to it small.

Where, on the contrary, the materials are coarse, we may suppose the rise to have been more rapid and the velocity of the current greater. When, again, large blocks have been transported, a more energetic movement is made manifest." What rate of tide-run is sufficient to move about "large blocks"? "Some indication of the duration of the uplift is afforded by the mass of material moved, and the distance traversed." Comparison with observed effects of tides seems to show that to move large blocks the duration must be very short if the uplift be moderate, or the uplift extremely great if the duration be moderate. The Tides also teach that high speeds are generated only in confined channels. The water pours through the Swinge, the Race of Alderney, the Goùliot Pass, or the Sound of Lihou; but in the open bay of St. Aubin's a thirty feet fall does not create any remarkably strong current off the shore.

There are two classes of catastrophe whose effects have probably magnified our ideas as to the potency of rapid rises or falls. When reservoirs or other dams burst, as in the St. Gervais calamity lately filling the newspapers; when earthquake waves roll in on to the land, as after the Krakatao eruption, direful disaster has been wrought. But neither catastrophe is properly comparable with the cases we have been considering. A reservoir is usually hundreds of feet above the sea-level. If its dam gives way the water flows off down this distance: the results, therefore, are analogous to what would happen if the land were elevated these hundreds of feet *instantaneously*. The earthquake wave, too, sweeps up the shore at a rate far exceeding what we can call 'rapid'; it rises its thirty or forty feet in a few seconds. Also its analogies belong to the case of a sinking, not of an uplifted, land.

We accordingly conclude that the effects of 'Rapid' emergence of land from below the sea will not differ from what we see happening daily between high water-mark and low, unless the rapidity is vastly greater than twenty or thirty feet in six hours; whilst even this moderate rapidity far transcends the powers of any agents with which we are at present acquainted.

IV.—The So-called Serpentines of the Lleyn.

By Catherine A. Raisin, B.Sc.

In the south-west of the Lleyn peninsula, the country inland is generally covered by drift, but the Survey map marks some isolated patches of rock as "Serpentine." When I first visited the district, with the kind encouragement of Professor Bonney, under whom I was continuing my work at University College, I made a collection of these so-called "Serpentines" from ten different localities. The one at Porth din lleyn had been shown by Professor Bonney to be mainly diabase,[1] and others of the examples have been since described in a previous number of this Magazine and elsewhere,[1] but we have yet no complete account. I have, therefore, attempted to give a short summary, as preliminary to some discussion of the district.

---

[1] On the Serpentine and associated Rocks of Anglesey; with a Note on the so-called Serpentine of Porth din lleyn. By Prof. T. G. Bonney, Q.J.G.S., 1881, vol. xxxvii. p. 48.

In four of the exposures the rocks, which are much alike, are recognised as diabase by Mr. Harker. Although abstaining from any definite opinion of their geological position, he notices certain characters in describing rocks, which, in eastern Carnarvonshire, are shown to be of Bala age. Masses from near Pwllheli and from other parts of the county certainly present much resemblance; and the four examples which I am considering might very well be intrusions along a N.E. to S.W. line, roughly in the direction of the strike or a strike fault. Lithologically they consist mainly of an ophitic dolerite undergoing a process of uralitisation, but the bosses also include more compact varieties, and many parts of the rock exhibit secondary changes due to crushing or development of minerals (often epidote).

1. *Trefgraig.*[2]—At least three varieties are shown in the quarry. (*a*) An ophitic dolerite, the felspar being somewhat decomposed, colourless augite, clear and well-preserved, occurring in one slide, in another a pale greenish hornblende. The latter mineral includes fibrous alteration, products and added growth, which sometimes surround a central core with a different crystalline orientation. Ilmenite is developed in the usual form of bars like sagenite. (*b*.) A finer-grained microporphyritic diabase. Veins which occur in the slide in some cases cross a felspar crystal, cementing it with felspar. A structure of this kind is attributed by Mr. Harker to infiltration along a line of "maximum shearing strain."[3] In the Trefgraig slide, however, the felspar of the vein, containing only very minute enclosures, contrasts sharply with the more decomposed substance of the original mineral. Each boundary is marked by bending of the crystal planes, and we should expect that any infiltration would have spread beyond this line. Again, although other parts of the vein are filled with serpentinous mineral, it seems at some places where it heals up broken augite to consist of felspar. (*c*). A fine-grained devitrified basalt or andesite, which contains a few slightly larger microliths of felspar and augite. It is associated with the dolerite first described, into which it seems to intrude, the larger crystals of the coarser rock being apparently snapped and sometimes crushed along the boundary line.

Some evidence of mechanical disturbance can be traced in the Trefgraig mass, and one specimen from near the edge is much crushed.

2. *Hendrefor.*[4]—The rock appears to be a uralitic diabase, retaining

---

[1] Notes on the Igneous Rocks of Lleyn. By J. V. Elsden, 1888, Geol. Mag. Decade III. Vol. V. p. 303. The Bala Volcanic Series of Carnarvonshire and Associated Rocks. By A. Harker, 1889, Cambridge, pp. 83, 86-88, etc.

[2] The Monian system of Rocks. Rev. J. F. Blake, Q.J.G.S., 1888, vol. xliv. p. 531. The Bala Volcanic Series. A. Harker, pp. 83, 87.

[3] The Bala Volcanic Series of Carnarvonshire. A. Harker, p. 26. See also Q.J.G.S., 1889, vol. xlv. p. 253, fig. 4.

[4] Mr. J. V. Elsden, *loc. cit.* p. 304. Mr. A. Harker, *loc. cit.* p. 87.

traces of ophitic structure, some of the hornblende being bluish-green and very dichroic. In one brecciated example, granular epidote is scattered abundantly over the slide, replacing crystals and forming veins.

3. *Tyhen.*[1]—A specimen better preserved apparently than those examined by Mr. Elsden consists of fairly clear felspar and augite with an intimate ophitic structure, and contains some viridite patches marking probably another pyroxenic or allied mineral. Ilmenite and pyrite are present. A much more compact rock appears to be enclosed within this fine dolerite, probably intruding into it, as at Trefgraig and Methlan.

4. *Methlan.*[2]—A diabase or ophitic dolerite with some alteration products. A compact dyke (1½" wide) is exposed by the side of the road.

Of the next four masses, two are described by Mr. Harker as including decomposed basalts.[3] The Careg Fawr crag is comparatively small and uniform, but at Porth din lleyn, as has been shewn, and also at Careg, a more complex mass occurs. Some examples from the latter place, like a specimen from near Hendre uchaf, show more pronounced microlithic development, but at all the localities we find a compact rock now altered, doubtless once glassy and of basic or fairly basic composition.

5. *Porth din lleyn.*—We are indebted to Professor Bonney for the description of these agglomerates and diabases, and for an examination which proved the absence of serpentine in this part of the Lleyn.[4] He described the rocks on the eastern coast of the promontory, and noted on the western side a similar diabase cut by amygdaloidal doleritic dykes, doubtless, as suggested, of later date.[5] Certain varieties are porphyritic, containing brighter green felspars within a dull green matrix. The ground mass in two rocks,[6] although they are not entirely identical, shows under the microscope many of the characters which occurred in certain specimens described by Mr. Elsden.[7] In one slide, epidote not only replaces crystals, but small rounded amygdules consist partly of that mineral, partly of viridite and of calcite. The porphyritic felspars are decomposed and saussuritic, often averaging ¼" in length. They form one point of likeness between these rocks and a specimen which I obtained further southward in the Lleyn. The well known Lambay porphyry also bears some resemblance in the character of

---

[1] Mr. J. V. Elsden, *loc. cit.* p. 304. Rev. J. F. Blake, *loc. cit.* p. 531. Mr. A. Harker, *loc. cit.* p. 87.

[2] Mr. J. V. Elsden, *loc. cit.* p. 304. Mr. A. Harker, *loc. cit.* p. 87.

[3] Mr. A. Harker, *loc. cit.* pp. 87, 88.

[4] Q.J.G.S., 1881, vol. xxxvii. pp. 48-50. Prof. T. G. Bonney.

[5] Q.J.G.S., 1881, vol. xxxvii. p. 50. Prof. T. G. Bonney. Compare also Q.J.G.S. 1888, vol xliv. p. 461. Mr. A. Harker. The Bala Volcanic Series of Carnarvonshire. Mr. A. Harker, p. 111; GEOL. MAG. 1880, Vol. VII. p. 457. Mr. A. S. Reid.

[6] One of the rocks was obtained from a boss on the grassy slope and has a bright green polished surface with streaks coloured by red halmatite. Sheep are continually rubbing themselves against the projecting stone, and the polishing is evidently due to their action.

[7] Mr. J. V. Elsden, *loc. cit.* p. 308.

its ground mass and of certain of its porphyritic felspars, although others differ somewhat in their narrower longer shape.[1] One of the Porth din lleyn examples occurs in the cliff of a small cove beyond the boat-house, as if it were a broad dyke; and a tangle of rocks on the beach suggests that the porphyritic greenstone has enclosed within it a compact diabase. Even in this case the intruding mass need not be of much later date, but might belong to the same volcanic period. This remark also applies to another rock at Porth din lleyn, which is a fairly typical basalt, dark purplish or black and microcrystalline; it appears to be similar to a mass on the beach at Porth wen, probably a dyke. On microscopic examination the latter exhibits lath-shaped felspars, much magnetite and some viridite. Further examples of this type occur to the south.

A junction with schists is mentioned by Mr. Elsden, but I could find no true metamorphic rocks. Schistose masses occur, the exact nature of which, in many cases, is extremely doubtful, but I have identified among them rocks of igneous origin. One slide proves that a diabase was veined by calcite, and that vein stuff and igneous rock were crushed together, so that the original character is masked; but amygdaloids and microliths of the ground-mass can still be recognized.

One rock of interest is exposed at low tide on the face of the promontory beyond the boat-house. It is a whiteish, sub-crystalline limestone, partly a breccia, the fragments of which project on the weathered fawn-coloured surface. The microscope slide seems to have the structure of limestone rock, apparently dolomitised, rather than of mineral vein, traversed, however, by clearly marked secondary veins of calcite and of quartz. Some rather dusty or silicified enclosures, which occur, seem to me to be not organic but of igneous origin. So the precipitation of the calcareous material may have been contemporaneous with volcanic eruptions.

6. *Careg Fawr* (South of Aberdaron).—Of this I need say little, as Mr. Harker has fully described all its important characteristics.[2] My slides do not happen to show any indications of a perlitic structure, but exhibit some of the larger cracks, which can be seen in the field sometimes limiting spheroids. The crag stands squarely up from the more level ground, as Mr. Harker states, like an intrusive mass; but it need not therefore belong to a later geologic period.

7. *Careg* (North of Aberdaron).—At this place, thick veins or masses of jasper are found, and limestone also occurs, but it is close to a small outcrop of the schistose rocks of the district. The dull purplish or greenish bosses and crags, which are doubtless those called "serpentine,"[3] are certainly igneous, apparently rather basic, and some originally glassy in character. At places spheroids can be

---

[1] I am much indebted to Mr. Thos. Davies, F.G.S., for kindly allowing me to see slides of the Lambay porphyry, and other Irish specimens, in the collection of the Mineralogical Department at the British Museum of Natural History.

[2] Mr. A. Harker, *loc. cit.* pp. 87, 88.

[3] The Geology of North Wales. Mem. of Geol. Survey, p. 230 (2nd ed.)

recognized, which are often shiny and palagonitic at their exterior. In small quarries and knolls on the western face of the hill, the rock is a green and purplish breccia. Although it presents some resemblance to an agglomerate, I am doubtful whether this is the true explanation. Many of the purple fragments are parts of spheroids, or are spheroids which are fissured, with the fine greenish matrix filling the interspaces. The microscope slides and the hand specimens prove a fluidal structure, certainly within, and probably outside, the small fragments, which even include some ordinary brown tachylite. I believe that a second movement of lava took place breaking a mass partially consolidated. This might have occurred within the pipe or neck of a small vent, but it is probable that the mass represents, at least in part, lava which flowed at the surface. At the top of the hill the rock is less disturbed, and consists, as shown by the microscope, of lath-shaped felspars within a matrix containing very minute augite, magnetite, and other incipient crystals. Thus we find at Careg gradations from tachylite to a micro-crystalline condition.

At one place on the eastern slope above the house is a green diabase with green porphyritic felspars. Ilmenite crystals glisten on the surface, and the slide exhibits the characters of a fine-grained dolerite, with decomposed felspars, very fresh white augite, and a constituent now green and serpentinised. The rock is doubtless intrusive and may be of later age.

8. *West of Hendre-uchaf.*—The patch of rock shown on the word Cil y bwth was probably exposed in a quarry, now completely grassed and marked only by a curve in the sloping ground; and the outcrop near Bachwen I also failed to see.

West of Hendre-uchaf I obtained specimens of an old basalt or diabase, compact in structure, with patches of purple and greenish colour. Microscopic examination shows the darker part to consist of lath-shaped felspars amid a black deposit of magnetite. The felspars exhibit a somewhat spherulitic grouping at places especially within the ferruginous aggregates. Small porphyritic crystals, often fractured or incomplete, slightly dichroic, yellow in colour, now serpentinised, are probably a hydrous ferro-magnesian silicate. A similar mineral forms small acicular or shuttle-shaped microliths.[1]

The rocks in the two remaining examples are clearly clastic.

9. *North of Braich anclwog.*—(Annelog). This small patch is a purple and green agglomerate. The rocks included, as seen on examination with the microscope, are basalt or andesite, consisting chiefly of felspar microliths, with more or less viridite or magnetite. Pyrite and secondary limonite occur. The pieces are rounded or sub-rounded, separated by palagonite; and calcite is deposited both within and between them. In the small quarry, the fragments are of no very great size, the larger being about six or seven inches

---

[1] See figures in Brit. Petrog. J. J. H. Teall, p. 14 (after Zirkel); U. S. Explorations of 40th parallel. Microc. Petrog. F. Zirkel, pl. i. fig. 20; Typical Forms of Crystallites. F. Rutley. Min. Mag. Dec. 1891, p. 268, fig. 17. Crenulites.

cross. There is apparently no stratification, and the mode of ccurrence seems to mark this as a small volcanic vent.

10. *North of Mynydd anelwog.*—(Annelog). The low crag near he spring consists of an ash, finer than, but of very similar aterials to, the agglomerate just described. Fragments of andesite r basalt are almost identical with the constituents of the preceding pecimen, and those of green viridite might be derived from the ame source, while occasionally a piece of scoria occurs. The ragments as seen by microscopic examination are small, with lightly irregular outline, and separated by strings of fine dust.

Thus all the patches of "serpentine," except the two mentioned, ave now been examined, with the result that not only is there no erpentine present but there is no uniformity in their character, and shall be able to show that similar rocks occur at many other places n the neighbourhood. Sometimes these "serpentines" are dolerites r compact diabases (andesites or basalts); sometimes they are true olcanic agglomerates. Although, in many cases, they are not nterbedded, some probably represent lava flows, or an ash of ransported fragments. This result, therefore, further illustrates he characters, which were first described by Professor Bonney from Porth din lleyn. His paper thus gave the key-note to the understanding, not only of that locality, but of others. The question of he geological age of these masses can only be discussed in onnection with the surrounding district, since it affords additional xamples of similar and allied rocks.

NOTICES OF MEMOIRS.

.—British Association for the Advancement of Science. Sixty-second Meeting, Edinburgh, August 3rd, 1892. President, Sir Archibald Geikie, LL.D., D.Sc., For. Sec. R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom.

Titles of Papers Read in Section (C), Geology, August 4–10.

Professor C. Lapworth, LL.D., F.R.S., F.G.S., President of Section.

The President's Address.

O. *W. Jeffs.*—Report of the Committee on Geological Photographs.

T. *Lomas.*—On the Glacial Distribution of the Riebeckite-Eurite of Ailsa Craig.

Dr. H. W. Crosskey.—Report of the Committee on Erratic Blocks.

J. W. Gray and *P. F. Kendall.*—The Cause of the Ice Age.

W. A. E. Ussher.—The Granites of Devon and Cornwall.

Dr. A. Irving.—The Malvern Crystallines.

J. G. Goodchild.—The St. Bees Sandstone and its Associated Rocks.

H. Woods.—The Igneous Rocks in the Neighbourhood of Builth.

A. G. C. Cameron.—Note on a Green Sand in the Lower Greensand, and on a Green Sandstone in Bedfordshire.

A. G. C. Cameron—The Fuller's Earth Mining Company at Woburn Sands.

C. E. de Rance.—Report of the Committee on the Circulation of Underground Waters.
B. N. Peach.—On a Widespread Radiolarian Chert formation, Arenig Age, in Southern Uplands of Scotland.
J. Horne.—On the Contact alteration of the Radiolarian Chert, along the margin of the Loch Doon Granite.
Dr. H. Hicks.—On the Grampian Series (Pre-Cambrian Rocks) of the Central Highlands.
J. F. Blake.—On the still-possible Cambrian Age of the Torridon Sandstone.
Prof. A. Blytt.—On some Calcareous Tufas in Norway.
Dugald Bell.—Alleged Proof of Submergence in Scotland during the Glacial Epoch. I. Chapelhall, Airdrie.
Dugald Bell.—Alleged Proofs of Submergence in Scotland during the Glacial Epoch. II. Clava and other Northern Localities.
Clement Reid.—Fossil Arctic Plants found near Edinburgh.
H. Coates.—The cuttings of the Crieff and Comrie Railway. Exhibition of Geological Specimens, Maps, and Photographs.
Prof. E. Hull.—The Physical Geology of Sinai and Palestine.
J. F. Blake.—On two tunnel-sections in the Cambrian of Carnarvonshire.
Dr. H. J. Johnston-Lavis.—Report of the Committee on the Volcanic Phenomena of Vesuvius.
Rev. E. Jones.—Report of the Committee on the Elbolton Cave.
B. Harrison.—Report of the Committee on the Excavations at Oldbury Hill.
Prof. T. G. Bonney.—On the Relation of the Bunter Pebbles of the English Midlands to those in the Old Red Sandstone conglomerates of Scotland.
A. Harker.—On Porphyritic Quartz in Basic Igneous Rocks.
Alexander Somervail.—On the Relations of the Rocks of the Lizard district.
B. N. Peach and *J. Horne.*—On the Ice-shed in the North-West Highlands during the Maximum Glaciation.
B. N. Peach and *J. Horne.*—On a Bone Cave in the Limestone of Assynt.
Prof. W. J. Sollas.—Report on the Committee on Investigating the Structure of a Coral Reef.
Miss M. Ogilvie.—Landslips in the St. Cassian Strata of the South Tyrol.
J. G. Goodchild.—On a Granite junction in Mull.
J. G. Goodchild.—The St. Bees' Sandstone and its associated Rocks.
J. J. H. Teall.—The Sequence of Gneissose Rocks.
Prof. W. J. Sollas.—Supposed Radiolarian Remains from the Slates of Howth.
Prof. J. W. Sollas.—Supposed Radiolarian Remains from the Culdaff Limestone.
E. T. Newton.—On Some Dicynodont and other Reptilian remains from the Elgin Sandstone.
Dr. R. H. Traquair.—On the Distribution of Fossil Fishes in the Edinburgh District.

M. *Laurie.*—The Eurypterid Fauna of the Silurian Rocks.
Prof. *T. R. Jones.*—Report of the Committee on Fossil Phyllopoda.
R. *B. Newton.*—On the occurrence of *Chonetes Pratti* (Davidson) in the Carboniferous Rocks of Western Australia.
A. *Smith Woodward.*—Report of the Committee on the Registration of Type Specimens.
G. *R. Vine.*—Report of the Committee on the Cretaceous Polyzoa.
C. *Davison.*—Report of the Committee on Earth Tremors.
A. *Harker.*—On Porphyritic Quartz in Basic Igneous Rocks.
Dr. *H. J. Johnston-Lavis.*—The Occurrence of Pisolitic Tuff in the Pentlands.
W. W. Watts.—Notes on some Limerick Traps.

TITLES OF PAPERS BEARING UPON GEOLOGY READ IN OTHER SECTIONS:—

Section A.—Mathematical and Physical Science.

Report of the Committee on Meteoric Dust.
Report of the Committee on the Seismological Phenomena of Japan.
Report of the Committee on Underground Temperature.

Section D.—Biology.

H. *O. Forbes.*—Remarks on a Series of Extinct Birds of New Zealand, recently discovered.
W. Carruthers, F.R.S.—On the structure of the stem of a typical *Sigillaria.*
T. *Hick.*—On *Calamostachys Binneyana.*
A. *C. Seward.* —Notes on specimens of *Myeloxylon* from the Millstone Grit and Coal-measures.

Section H.—Anthropology.

H. *O. Forbes.*—On the Contemporaneity of Man and the Moa.
Report of the Prehistoric Inhabitants Committee.

II.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, EDINBURGH, 1892.

Address to the Geological Section by PROFESSOR C. LAPWORTH, LL.D., F.R.S., F.G.S., President of the Section.

IT has, I believe, been the rule for the man who has been honoured by election o the Chair of President of this Geological Section of the British Association to ddress its members upon the recent advances made in that branch of geology in hich he has himself been most immediately interested. It is not my intention pon the present occasion to depart from this time-honoured custom; for it has oth the merit of simplicity and the advantage of utility to recommend it. In his way each branch of our science, as it becomes in turn represented, not only ubmits to the workers in other departments a report of its own progress, but resents by implication a broad sketch of the entire geological landscape, seen hrough the coloured glasses, it may be, of divisional prejudice, but at any rate nstructive and corrective to the workers in other departments, as being taken rom what is to them a novel and an unfamiliar point of view.

Now every tyro in geology is well aware of the fact that the very backbone of eological science is constituted by what is known as stratigraphical geology, or he study of the geological formations. These formations, stratified and nstratified, build up all that part of the visible earth-crust which is accessible to the investigator. Their outcropping edges constitute the solid framework, the surface of which forms the physical geography of the lands of the present day, and their internal characters and inter-relationships afford us our only clues to the physical geographies of bygone ages. Within them lies enshrined all that we may ever hope to discover of the history and the development of the habitable world of the past.

These formations are to the stratigraphical geologist what species are to the biologist, or what the heavenly bodies are to the astronomer. It was the discovery of these formations which first elevated geology to the rank of a science. In the working out of their characters, their relationships, their development, and their origin, geology finds its means, its aims, and its justification. Whatever fresh material our science may yield to man's full conception of nature, organic and inorganic, must of necessity be grouped around these special and peculiar objects of its contemplation.

When the great Werner first taught that our earth-crust was made up of superimposed rock-sheets or formations arranged in determinable order, the value of his conclusions from an economic point of view soon led to their enthusiastic and careful study; but his crude theory of their successive precipitation from a universal chaotic ocean disarmed the suspicions of the many until the facts themselves had gained such a wide acceptance that denial was no longer possible. But when the greater Scotchman, Hutton, asserted that each of these rock-formations was in reality nothing more nor less than the recemented ruins of an earlier world, the prejudices of mankind at large were loosed at a single stroke. Like Galileo's assertion of the movement of the globe, this demanded such an apparently undignified and improbable mode of creation that there is no wonder that, even down to the present day, there still exist some to whom this is a hard saying, to be taken, if taken at all, in homœopathic doses and with undisguised reluctance.

Hutton as regards his philosophy was, as we know, far in advance of his time. With all the boldness of conviction he unflinchingly followed out these ideas to their legitimate results. He claimed that as the stratified formations were composed of similar materials—sands, clays, limestones, and muds—to those now being laid down in the seas around our present coasts, they must, like them, have been the products of ordinary natural agencies of rain, rivers, and sea waters, internal heat and external cold, acting precisely as they act now. And, further, as these formations lie one below the other, in apparently endless downward succession, and all formed more or less of these fragmentary materials, so the present order of natural phenomena must have existed for untold ages. Indeed, to the commencement of this order he frankly admits 'I see no trace of a beginning or sign of an end.'

The history of the slow acceptance of Hutton's doctrines, even among geologists, is, of course, perfectly familiar to us all. William Smith reduced the disputed formations to order, and showed that not only was each composed of the ruins of a vanished land, but that each contained in its fossils the proof that it was deposited in a vanished sea inhabited by a special life creation. Cuvier followed, and placed it beyond question that the fossilised relics of these departed beings were such as made it absolutely unquestionable that these creatures might well have inhabited the earth at the present day. Lyell completed the cycle by demonstrating stage by stage the efficiency of present natural agencies to do all the work required for the degradation and rebuilding of the formations. Since his day the students of stratigraphical geology have universally acknowledged that in the study of present geographical causes lies the key to the geological formations and the inorganic world of the past.

In this way the road was paved for Darwin and the doctrine of descent. The aid which had been so ungrudgingly afforded by biology to geology was repaid by one of the noblest presents ever made by one science to another. For the purposes of geology, the science of biology had practically completed a double demonstration: first, that the extinct life discernible in the geological formations was linked inseparably with the organic life of the present; and, second, that every fossil recognised by the geologist was the relic of a creature that might well have existed upon the surface of the earth at the present time. Geology repaid its obligation to biology by the still greater twofold demonstration: first, that in the economy of nature the most insignificant causes are competent to the grandest effects, if only a sufficiency of time be granted them; and, second, that in the geological formations we have the evidences of the actual existence of those mighty eons in which such work might be done.

The doctrine of organic evolution would always have remained a metaphysical dream had geology not given the time in which the evolution could be accomplished. The ability of present causes to bring about slow and cumulative changes in the species is, to all intents and purposes, a biological application of Hutton's ideas with respect to the original geological formations. Darwin was a biological evolutionist, because he was first a uniformitarian geologist. Biology is preeminent to-day among the natural sciences, because its younger sister, Geology, gave it the means.

But the inevitable consequence of the work of Darwin and his colleagues was that the centre of gravity, so to speak, of popular regard and public controversy was suddenly shifted from stratigraphical geology to biology. Since that day stratigraphical geology, to its great comfort and advantage, has gone quietly on its way unchallenged, and all its more recent results have, at least by the majority of the wonder-loving public, been practically ignored.

Indeed, to the outside observer it would seem as if stratigraphical geology for the last thirty years had been practically at a standstill. The startling discoveries and speculations of the brilliant stratigraphists of the end of the last century and first half of the present forced the geology of their day into the very front rank of the natural sciences, and made it perhaps the most conspicuous of them all in the eyes of the world at large. Since that time, however, their successors have been mainly occupied in completing the work of the great pioneers. The stratigraphical geologists themselves have been almost wholly occupied in laying down upon our maps the superficial outlines of the great formations, and working out their inter-relationships and subdivisions. At the present day the young stratigraphical student soon learns that all the limits of our great formations have been laid down with accuracy and clearness, and finds but little to add to the accepted nomenclature of the time.

Our palæontologists also have equally busied themselves in working out the rich store of the organic remains of the geological formations, and the youthful investigator soon discovers that almost every fossil he is able to detect in the field has already been named, figured, and described, and its place in the geological record more or less accurately fixed.

In France, in Germany, in Norway, Sweden, and elsewhere, in Canada and in the United States, work as thorough and as satisfactory has been accomplished, and the local development of the great stratified formations and their fossils laid down with detail and clearness.

Many a young unfledged but aspiring geologist alive to these facts, and contrasting the well-mapped ground of the present time with the virgin lands of the days of the great pioneers, finds it hard to stifle a feeling of keen regret that there are nowadays no new geological worlds to conquer, no new systems to discover and name, and no strange and unexpected faunas to unearth and bring forth to the astonished light of day. The youth of stratigraphical geology, with all its wonder and freshness, seems to have departed, and all that remains is to accept, to commemorate, and to round off the glorious victories of the dead heroes of our science.

But to the patient stratigraphical veteran, who has kept his eyes open to discoveries new and old, this lull in the war of geological controversy presents itself rather as a grateful breathing time; the more grateful as he sees looming rapidly up in front the vague outlines of those oncoming problems which it will be the duty and the joy of the rising race of young geologists to grapple with and to conquer as their fathers met and vanquished the problems of the past. He knows perfectly well that Geology is yet in her merest youth, and that to justify even her very existence there can be no rest until the whole earth-crust and all its phenomena, past, present, and to come, have been subjected to the domain of human thought and comprehension. There can be no more finality in Geology than in any other science; the discovery of to-day is merely the stepping-stone to the discovery of to-morrow; the living theory of to-morrow is nourished by the relics of its parent theory of to-day.

Now if we ask what are these formations which constitute the objects of study of the stratigraphical geologist, I am afraid that, as in the case of the species of the biologist, no two authorities would agree in framing precisely the same definition. The original use of the term formation was of necessity lithological, and even now the name is most naturally applied to any great sheet of rock which forms a component member of the earth-crust; whether the term be used specifically for a thin homogeneous sheet of rock like the Stonesfield slate, ranging over a few square miles; or generically for a compound sheet of rock, like the Old Red Sandstone, many thousands of feet in thickness, but whose collective lithological characteristics give it an individuality recognizable over the breadth of an entire continent.

When Werner originally discovered that the 'formations' of Saxony followed each other in a certain recognizable order, a second characteristic of a formation became superposed upon the original lithological conception—namely, that of determinate 'relative position.' And when William Smith proved that each of the formations of the English Midlands was distinguished by an assemblage of organic remains peculiar to itself, there became added yet a third criterion —that of the possession of 'characteristic fossils.'

But these later superposed conceptions of time—succession and life-type—are far better expressed by dividing the geological formations into zoological *zones*, on the one hand, and grouping them together, on the other hand, into chronological *systems*. For in the experience of every geologist he finds his mind instinctively harking back to the bare lithological application of the word 'formation,' and I do not see that any real advantage is gained by departing from the primitive use of the term.

A 'zone,' which may be regarded as the *unit of zoological succession*, is marked by the presence of a special fossil, and may include one or many subordinate formations. A *system*, which is, broadly speaking, the *unit of geological time or succession*, includes many 'zones,' and often, but not always, many 'formations.' A *formation*, which is the *unit of geological stratigraphy*, is a rock sheet composed of many strata possessing common lithological characters. The formation may be simple, like the chalk, or compound, like the New Red Sandstone, but, simple or compound, local or regional, it must be always recognizable, geographically and geologically, as a lithological individual.

As regards the natural grouping of these lithological individuals as such, fair progress has been made of late years, and our information is growing apace. We know that there are at any rate three main groups: 1st. The stratified formations due to the action of moving water above the earth-crust. 2nd. The igneous formations which are derived from below the earth-crust. 3rd. The metamorphic formations which have undergone change within the earth-crust itself. We know also that of these three the only group which has hitherto proved itself available for the purpose of reading the past history of the globe is that of the stratified formations.

Studying these stratified formations therefore in greater detail, we find that they fall naturally in their turn into two sets, viz.: a mechanical set of pebble beds, sandstones and clays formed of rock fragments washed off the land into the waters, and an organic set of limestones, chalk, etc., formed of the shells and exuviæ of marine organisms.

But when we attempt a further division of these two sets our classification soon begins to lose its definiteness. We infer that some formations, such as the Old Red and the Triassic, were the comparatively rapid deposits of lakes and inland seas; that others, like the Coal-measures, London-clay, etc., were the less rapid deposits of lagoons, river valleys, deltas, and the like; that others, like our finely laminated shales and clays of the Silurian and Jurassic, were the slower deposits of the broader seas; and finally, that others, like our Chalk and Greensand, were possibly the extremely slow deposits of the oceanic deeps.

Nevertheless, after looking at the formations collectively, there remains no doubt whatever in the mind of the geologist that their mechanical members are the results of the aqueous degradation of vanished lands, and that their organic members are the accumulated relics of the stony secretions of what once were living beings. Neither is there any possibility of escape from the conclusion that they have all been deposited by water in the superficial hollows of the sea-bottoms and ocean floors of the earth-crust of their time.

In the life of every individual stratified formation of the mechanical type we always distinguish three stages: first, the stage of erosion and transportation, vhich the rock fragments were worn off the rocks of the higher ground and hed down by rain and rivers to the sea; second, a stage of deposition and solidation below the surface of the quiet waters; and third, a final stage in ch the completed rock-formation was bent and upheaved, in part at least, into d land. In the formations of the organic type three corresponding stages are ally discernable: first, the period of mineral secretion by organized beings; ond, the period of deposition and consolidation; and third, the final period of l elevation in mass. But one and all, mechanical and organic alike, they bear their composition, in their arrangement, and in their fossils, abundant and sistible evidence that they *were* the products and that now they are the morials of the physical geography of their time.

;uided by the principles of Hutton and Lyell, geologists have worked out with at care and completeness the effects of those agencies which rule in the first of se three life-stages in the history of a mechanical formation. No present logical processes are more familiar to the young geologist than those of udation, erosion, and transportation. They form together the subject-matter that most wonderful fascinating chapter in geology which from its modest ming among the quiet Norfolk Sandhills sweeps upwards and onwards without reak to its magnificent close on the brink of the gorge of the Colorado. But knowledge of the detailed processes of deposition and consolidation which rule the second stage is still exceedingly imperfect, although a flood of light has n thrown upon the subject by the brilliant results of the *Challenger* Expedition. d we are compelled to admit that our knowledge of the operations of those ncies which rule in the processes of upheaval and depression is as yet almost ; and what little we have already learnt of the effects of these agencies is the y of hosts of conflicting theories that merely serve to annoy and bewilder the rking student of the science.

But not one of the formative triad of detrition, deposition, and re-elevation can st without the others. No detrition is possible without the previous upheaval of rock-sheet, from which material can be removed; no deposition is possible thout the previous depression of the rock-sheet, which forms the basin in which fragmentary material can be laid down.

Our knowledge, therefore, of the origin and meaning of any geological formation atever can at most be only fragmentary until this third chapter in the life-history the geological formation has been attacked in earnest.

Now all the rich store of knowledge we possess respecting the first stage in the of a geological formation has been derived from a comparison of certain enomena which the stratigraphical geologist finds in the rock formations of the st, with correspondent phenomena which the physical geographer discovers on surface of the earth at the present. And all that we know of the second stage ain has been obtained in precisely the same way. Surely analogy and common se both teach us that all which is likely to be of permanent value to us as, ards the final stage of elevation and depression must be sought for in the same ection.

Within the last twenty years or so many interesting and vital discoveries have n made in the stratigraphy of the rock formations, which bear largely upon this scure chapter of elevation and depression. And I propose on this occasion that try to summarise a few of these new facts, and then, reading them in njunction with what we actually know of the physical geography of the present y, try to ascertain how such mutual agreement as we can discover may serve to l the stratigraphical geologist in his interpretation of the true meaning of the ological formations themselves. We may not hope for many years to come to d the whole of this geological chapter, but we may perhaps modestly essay an erpretation of one or two of the opening verses.

In the physical geography of the present day we find the exterior of our raqueous globe divided between the two elements land and water. We know at the solid geological formations exist everywhere beneath the visible surface of lands, but of their existence under the present ocean floor we have as yet no solute certainty. We know both the form of the surface and the composition of, surface of the continental parts of the lithosphere; we only know as yet even outline the form of its oceanic portions. The surface of each of our great continental masses of land resembles that of a long and broad arch-like form, of which we see the simplest type in the New World. The surface of this American arch is sagged downwards in the middle into a central depression which lies between two long marginal plateaux, and these plateaux are finally crowned by the wrinkled crests which form our modern mountain systems. The surface of each of our ocean floors exactly resembles that of a continent turned upside down. Taking the Atlantic as our simplest type, we may say that the surface of each ocean basin resembles that of a mighty trough or syncline, buckled up more or less centrally into a medial ridge, which is bounded by two long and deep marginal hollows, in the cores of which still deeper grooves sink to the profoundest depths. This complementary relationship descends even to the minor features of the two.

Where the great continental sag sinks below the ocean level we have our gulfs and our Mediterranean, seen in our type continent as the Mexican Gulf and Hudson Bay. Where the central oceanic buckle attains the water-line we have our oceanic islands, seen in our type ocean as St. Helena and the Azores. Although these apparent crust-waves are neither equal in size nor symmetrical in form, this complementary relationship between them is always discernible. The broad Pacific depression seems to answer to the broad elevation of the Old World —the narrow trough of the Atlantic to the narrow continent of America.

Every primary wave of the earth's surface is broken up into minor waves, in each of which the ridge and its complementary trough are always recognisable. The compound ridge of the Alps answers to the compound Mediterranean trough; the continuous western mountain chain of the Americas to the continuous hollow of the Eastern Pacific which bounds them; the sweep of the crest of the Himalaya to the curve of the Indo-Gangetic depression. Even where the surface waves of the lithosphere lie more or less buried beneath the waters of the ocean and the seas, the same rule always obtains. The island chains of the Antilles answer to the several Caribbean abysses, those of the Ægean Archipelago answer to the Levantine deeps.

Draw a section of the surface of the lithosphere along a great circle in any direction, the rule remains the same: crest and trough, height and hollow, succeed each other in endless sequence, of every gradation of size, of every degree of complexity. Sometimes the ridges are continental, like those of the Americas; sometimes orographic, like those of the Himalaya; sometimes they are local, like those of the English Weald. But so long as we do not descend to minor details we find that every line drawn across the earth's surface at the present day rises and falls like the imaginary line drawn across the surface of the waves of the ocean. No rise of that line occurs without its complementary depression; the two always go together, and must of necessity be considered together. Each pair constitutes one of those geographical units of form of which every continuous direct line carried over the surface of the lithosphere of our globe is made up. This unit is always made up of an arch-like rise and a trough-like depression which shade into each other along a middle line of contrary curvature. It resembles the letter S, or Hogarth's line of beauty, and is clearly identical in form with the typical wave of the physicist. Here, then, we reach a very simple and natural conclusion, viz., the surface of the earth-crust of the present day resembles that of a series of crust-waves of different lengths and different amplitudes, more or less irregular and complex, it is true, but everywhere alternately rising and falling in symmetrical pairs like the waves of the sea.

Now this rolling wave-like earth-surface is formed of the outcropping edges of the rock formations which are the special objects of study of the stratigraphical geologist. If, therefore, the physiognomy of the face of our globe is any real index of the character of the personality of the earth-crust beneath it, these collective geographical features should be precisely those which answer to the collective structural characters of the geological formations.

In the earlier days of geology one of the first points recognised by our stratigraphists was the fact that the formations were successive lithological sheets, whose truncated outcropping edges formed the present surface of the land, and that these sheets lay inclined at an angle one over the other, as William Smith quaintly expressed it, like a tilted 'pile of slices of bread and butter.' But as discovery progressed the explanation of the arrangement soon became evident. The formations revealed themselves as a series of what had originally been deposited as horizontal sheets, lying in regular order one over the other, but which had been subsequently bent up into alternating arches and troughs (i.e. the anticlines and synclines of the geologist), while their visible parts, which now constitute the surface of our habitable lands, were simply those parts of the formation which are cut at present by the irregular plane of the present earth's surface. All those parts of the great arches and troughs formerly occurring above that plane have been removed by denudation; all those parts below that plane lie buried still out of sight within the solid earth-crust, although in every geological section of sufficient extent it was seen that the anticline or arch never occurred without the syncline or trough—in other words, that there was never a rise without a corresponding fall of the stratum. Yet it is only of late years that the stratigraphical geologist has come clearly to recognize the fact that the anticline and syncline must be considered together, and must be united as a single crust-wave, for the arch is never present without its complementary trough, and the two together constitute the tectonic or orographic unit. *The Fold*, the study of which, so brilliantly inaugurated by Heim in his 'Mechanismus der Gebirgsbildung,' is destined, I believe, in time, to give us the clue to the laws which rule in the local elevation and depression of the earth-crust, and furnish us with the means of discovery of the occult causes which lie at the source of those superficial irregularities which give to the face of our globe its variety, its beauty, and its habitability.

We have said already that this wave or fold of the geologist resembles that of the wave of the physicist.

Now we may regard such a wave as formed of two parts, the arch-like part above and the trough-like part below. The length of the wave is naturally the length of that line joining the outer extremities of the arch and trough, and passing through the centre node or point of origin of the wave itself, which bisects the line of contrary curvatures. The amplitude of the wave is the height of the arch added to the depth of the trough. Now the arch part of such a wave, if perfectly symmetrical, may clearly be regarded as belonging either to a wave travelling to the right, in which case the complementary trough is the one in that direction, or it may be regarded as belonging to a wave travelling to the left, in which case its trough must be the one in that direction. But as in the case of the sea wave, the advancing slope of the wave is always the steeper, and the real centre of the wave must lie half-way down this steeper slope; so there is no difficulty in recognizing the centre of a geological fold and its real direction of movement.

The fold of the geologist differs from the ordinary wave of the physicist, essentially in the fact that even in its most elementary conception, as that of a plate bent by a pressure applied from opposite sides, it necessarily includes the element of thickness. And this being the case, the rock sheet which is being folded and curved has different layers of its thickness affected differently; in the arch of the fold the upper layers of the rock sheet are extended, while its lower layers are compressed. On the contrary, in the trough of the fold the upper layers are compressed and the lower layers are extended. But in both arch and trough alike there exists a central layer, which, beyond taking up the common wave-like form, remains practically unaffected.

But the geological fold has in addition to length and thickness the further element of breadth, and this fact greatly complicates the phenomena.

But many of the movements which take place in a rock sheet which is being folded, or in other words those produced by the bending of a compound sheet composed of many leaves, can be fairly well studied in a very simple experiment. Take an ordinary large note-book, say an inch in thickness, with flexible covers, rule carefully a series of parallel lines across the edges of the leaves at the top of the book, about ½ of an inch apart, and exactly at right angles to the plane of the cover. Then, holding the front edges loosely, press the book slowly from back and front into an S-like form until it can be pressed no further. As the wave grows it will be noticed that the cross lines which have been drawn on the upper edge of the book remain fairly parallel throughout the whole of the folding process, except in the central third of the book, where they arrange themselves into a beautiful sheaf-like form, showing how much the leaves of the book have sheared or slidden over each other in this central portion. It will also be seen when the S is complete that the book has been forced into a third of its former breadth. It is clear that the wave the book now forms must be regarded as made up of three sections: viz. a section forming the outside of the trough on the one side, and a section forming the outside of the arch on the other, and a central or common section, which may be regarded either as uniting or dividing the other two.

As this experiment gives us a fair representation of what takes place in a geological fold, we see at a glance that the geologist is forced to divide his fold into three parts—an arch limb, a trough limb, and a middle limb—which latter we may call the *copula* or the *septum*, according as we regard it as connecting or dividing the other two. Our note-book experiment, therefore, shows us also that in the trough limb and the arch limb the leaves or layers undergo scarcely any change of relative position beyond taking on the growing curvature of the wave. But the layers in the central part, or *septum*, undergo sliding and shearing. It will be found also, by gripping the unbound parts of the book firmly and practicing the folding in different ways, that this *septum* is also a region of warping and twisting. This simple experiment should be practised again and again until these points are apparent, and the various stages of the folding process become clear; the surface of the book being forced first into a gentle arch-like rise with a corresponding trough-like fall, then stage by stage the arch should be pushed over on to the trough until the surfaces of the two are in contact and the book can be folded no further.

(*To be continued.*)

REVIEWS.

I.—Argiles de Speeton et leurs Équivalents. By A. Pavlow and G. W. Lamplugh. Extracted from the "Bulletin de la Société Impér. des Naturalistes de Moscou," Nos. 3 and 4, 1891. With eleven plates (Moscow, 1892).

THAT the study of life-zones furnishes the key to the elucidation of the relationship of fossiliferous rocks, however widely separated geographically, has long been recognised by palæontologists, and this lesson is enforced anew in the admirable monograph before us.

The authors divide their work into three parts; the first (pp. 1–33) contains a description of the beds at Speeton (Speeton Clay) and their equivalents in Lincolnshire, by Mr. Lamplugh; the second (pp. 34–155) gives a description, written by M. Pavlow, of those forms of Mesozoic Cephalopods—Belemnites and Ammonites—which are of the greatest importance for purposes of comparative stratigraphy. These fossils are compared with the fossils of other countries, chiefly with Russian forms, of which some are figured as well as described. This part of the work is preceded by a table (pp. 36–37) indicating the sub-divisions of the Jurassic and Lower Cretaceous beds of the neighbourhood of Moscow, and of the lower Volga region (Bas Wolga). Furthermore, M. Pavlow deals with the relationship between the Speeton and Lincolnshire beds and those of other countries (pp. 156–201).

The material upon which the memoir under review was based consisted in the main of Mr. Lamplugh's collection of fossils made at Speeton and in Lincolnshire, supplemented by many specimens lent to the authors by the officials connected with some of the leading Continental and British Museums.

In order to make clear the remarks which follow we here reproduce part of a stratigraphical table furnished by M. Pavlow, showing the different "zones" into which the Speeton and Russian beds have been divided.

Tealby Limestone.	B. Zone of *Hoplites Deshayesi* and *Belemnites brunvicensis.*	Zone of *Hoplites Deshayesi* and *Amaltheus bicurvatus.*	Unfossiliferous sands.
Tealby Clay.	C. 1—C. 6. Zone of *Olcostephanus Decheni* and *O. speetonensis.*	Zone of *Olcostephanus Decheni* and *O. discofalcatus.*	Sandstone of Worobiewo with *Olcostephanus Decheni* and *O. discofalcatus.*
	C. 6—C. 7. Zone of *Olcostephanus subinversus* and *Belemnites jaculum.*	Zone of *Olcostephanus versicolor.*	
Upper part of the ferruginous rock of Claxby, with *Hoplites regalis* and *Belemnites jaculum.*	C. 8—C. 11. Zone of *Hoplites regalis*, *Astieria Astieri* (type), *Belemnites jaculum.*	Wanting, or is represented by sands poor in fossils (*Belemnites subquadratus*).	Zone represented perhaps by orange sands with black phosphatic nodules (with *Hoplites rjasanensis*).
Lower part of the ferruginous rock of Claxby, with *Olcostephanus Blakei*, *Belemnites russiensis*, etc.	D. 1—D. 3. Zone of *Olcostephanus gravesiformis*, *O. Keyserlingi*, *Belemnites lateralis*, etc.	Zone of *Olcostephanus gravesiformis*, *O. Keyserlingi*, *Belemnites lateralis*, etc.	Sands almost without fossils (with remains of plants).
Spilsby Sandstone with *Olcostephanus subditus.*	D. 4—D. 8. Zone of *Olcostephanus fragilis*, cf. *O. subditus*, etc.	Zones of *Olcostephanus Kaschpuricus*, and *O. subditus.*	Zones of *Olcostephanus nodiger* and *O. subditus.*
Schists with *Discina latissima* and crushed Ammonites.	"Coprolite bed." E.	Zone with *Ammonites giganteus.* Zone with *Virgatites virgatus.*	Zone with *Ammonites triplicatus* and *A. Blakei.* Zone with *Virgatites virgatus.*
	Beds F. with *Belemnites magnificus*, *B. porrectus*, and crushed Ammonites.	Beds with *Belemnites magnificus* and the first representatives of the Virgati (not yet completely studied).	
Kimmeridgian slates.	Beds with *Hoplites pseudomutabilis.*	Beds with *Hoplites pseudomutabilis.*	

These may be taken in descending order, attention being directed chiefly to the lower Volga region, of which the series of beds is the most complete. Below the Gault in this region there are clays containing concretions of marly limestone, and characterized by *Hoplites Deshayesi*, *Amaltheus bicurvatus*, and by large forms of *Ancyloceras*, which are found both in concretions and in the clay itself. The presence of Gault cephalopods clearly indicates the horizon to which these clays belong. The Gault clays rest upon a thick series of more or less marly and gypsiferous clays, of which the upper part is poor in fossils, making it difficult to establish the lower boundaries of the Gault. But a little lower down two horizons are apparent, characterized by different Ammonites; the upper one with *Olcostephanus* (*Simbirskites*) *Decheni*, *S. discofalcatus*, *S. progrediens*, *S. umbonatus*, *S. speetonensis* (*fasciato-falcatus*, Lah.), *S. Barboti*, *Belemnites Jasikowi*, *B. brunsvicensis*, *B. absolutiformis*, the lower, which is thinner, containing *Simbirskites versicolor*, *S. inversus*, *Belemnites Jasikowi*, *B. absolutiformis*. Comparing this part of the Simbirsk section with that of Speeton (see Table) the striking resemblance between the two faunas is apparent, as also the similarity in the order of their succession. The number of forms common to both leaves no room to doubt that in the Simbirsk horizon we have the exact representative of the zones of *Olcostephanus* (*Simbirskites*) *speetonensis*, and *S. subinversus* of Speeton. There are, it is true, some dissimilarites between the beds of the two countries, but these are unimportant, and fresh researches might completely negative them. The zone of *S. Decheni* and *S. discofalcatus* is developed also in the neighbourhood of Moscow (Grés de Worobiewo) and contains *Crioceras Matheroni*. On descending lower in the series, however, the striking resemblance between the Russian and Speeton beds is no longer discernible. For, while at Speeton the succeeding zone (c. 8 to c. 11) is characterized by *Hoplites regalis*, *Holcodiscus rotula*, *Astieria Astieri*, *Hoplites Roubaudi*, *Belemnites jaculum* (representing the upper part of the "Claxby Ironstone" of Lincolnshire), this zone is entirely wanting in the Simbirsk[1] region. Its absence is the more remarkable since the following zone, which forms the base of the *Hoplites regalis* beds of Speeton, is common to both countries, although in Russia it is only developed in certain places. The zone in question (D. 1 to D. 3) is met with in the neighbourhood of Syzran (village of Kachpour), and its stratigraphical position is found to be above that of the upper zone of the first stage of Rouillier (= Volgien supérieur). It here contains *Olcostephanus* (*Polyptychites*) *Keyserlingi*, *P. ramulicosta*, *P. gravesiformis*, *Belemnites lateralis*, *B. subquadratus*, and many other forms. No trace of this interesting fauna has been met with in the environs of Moscow. Remains of plants in arenaceous beds, of Wealden or Purbeck age, are found here, and these beds rest upon the upper stage of Rouillier, which near Syzran forms the base of the "Petchorian" stage[1] The Rouillier stage is very rich in fossils and its fauna has been carefully worked up. It is divided into two zones, the upper of which contains *Olcostephanus* (*Craspedites*) *nodiger*, *C. kaschpuricus*, and *Oxynoticeras subclypeiforme*, and the lower contains *Olcostephanus* (*Craspedites*) *subditus*, *C. fragilis*, and *Oxynoticeras catenulatum*. *Belemnites lateralis*, *B. russiensis* and *B. mosquensis* are found in both zones; *Belemnites subquadratus* is also met with, though rarely.

---

[1] Simbirsk is a province situated in the western part of East Russia, nearly due west of Moscow.

Turning again to Speeton we find that the beds there (D. 4 to D. 8) corresponding with the upper stage of Rouillier are those situated immediately below D. 1 to D. 3, and that they contain the following Cephalopods, viz., *Belemnites lateralis*, *B. russiensis*, *B. subquadratus*, *B. explanatoides*, *Olcostephanus* (*Craspedites*) *fragilis*, *C. subditus*, and *Oxynoticeras*, cf. *catenulatum*. Excluding the two last-named Ammonites, which were found to be too young for decisive identification, the list may be completed by the Cephalopods of Lincolnshire of corresponding horizon (Spilsby Sandstone). This supplies an undoubted *Craspedites subditus*, so that there remains only *Oxynoticeras catenulatum* upon which any doubt might be thrown. But even if the last-named species did not exist at Speeton, the number of forms common to the Russian and English horizons in question would be sufficient to prove the relationship between them.

We now reach the beds forming the base of the *Craspedites subditus* and *C. fragilis* beds, which in Russia are rich in Ammonites of the Virgati group. Two zones have been observed up to the present time, viz., the zone of *Virgatites virgatus*, and *V. Pallasi*, and that of *V. triplicatus* and *V. Blakei*. Representing these zones at Speeton there are (1) the "Coprolite bed," (2) the bituminous schists containing crushed Ammonites, and *Belemnites magnificus*, *B. porrectus*, and *B. obeliscoides*, which are observed at Speeton, below the *Belemnites lateralis* beds. The Ammonites found in the "Coprolite bed" are too fragmentary to be identified with exactness; but the following species were approximately determined, viz., *Virgatites*, cf. *V. Panderi*, *Virgatites*, cf. *V. Tchernyschovi*, *Virgatites*, cf. *V. scythicus*, *Virgatitus*, cf. *V. dorsoplanus*, *Virgatites*, cf. *V. miatschkoviensis*, *Perisphinctes lacertosus*. Going down still lower in the stratigraphical series undoubted Kimmeridgian beds are met with containing *Hoplites eudoxus*, *H. pseudomutabilis*, and *H. subundaræ*. The beds are the same as those which constitute the base of the Virgati beds in Russia. Thus, even putting aside palæontological evidence, the stratigraphy alone would suffice to prove that the "Coprolite bed" E, and the bituminous schists forming its base correspond to the Virgati beds of the Russian Jurassic. The palæontological evidence, however, is not so convincing, owing to the bad state of preservation of the Speeton fossils, and an imperfect knowledge of the lowest zone of the Virgati beds. Notwithstanding this, the regular succession of zones in Russia and England, holding a similar fauna, justifies the anticipation that the parallelism between the Upper Jurassic and Neocomian beds of Russia, and those of Western Europe, may yet be established upon the firm basis of palæontological facts.

---

[1] This sub-division has been so designated by M. Pavlow. It is a well developed horizon, characterized by a special fauna. It was first discovered by Keyserling, who described it in his "Wissenschaftliche Beobachtungen auf einer Reise in das Petschora Land, 1846."

In his chapter on the comparative stratigraphy of the Speeton Clay (pp. 156–201), M. Pavlow cites the opinions of Toucas, Oppel, Blake, C. Struckmann, Nikitin, Tchernychew, and others, on the question of the age of the Portlandian and Tithonic. While not discussing the point as to whether these formations belong to the Cretaceous or to the Jurassic, M. Pavlow observes that the history of the development of the faunas, so far as they are known, is distinctly opposed to the division of the Tithonic and the Portlandian between the two systems.

The following new species of Belemnites are described by M. Pavlow, viz., *Belemnites obeliscoides*, *B. explanatoides*, *B. Rouillieri*, *B. mosquensis*, *B. breviaxis*, *B. cristatus*, *B. obtusirostris*, *B. speetonensis*. A chapter upon the classification of Belemnites (pp. 89–96) follows the description of the species, the divisions adopted being based upon those of Neumayr, viz., (1) *Notocœli*, (2) *Bipartiti*, (3) *Dilatati*, (4) *Suprasulcati* (= *Canaliculati*, Neumayr, non Zittel), (5) *Acuarii*, (6) *Infradepressi*. Of Ammonites the following new subgenera and species are described, viz., *Virgatites* (=Ammonites of the group *Virgati*, auct.); *Craspedites* (=Olcostephani of the group *O. subditus*); *Polyptychites* (=Olcostephani of the group *O. polyptychus*), *Olcostephanus* (*Polyptychites*) *triplodiptychus*, *O.* (*P.*) *ramulicosta*, *O.* (*P.*) *Beani*, *O.* (*P.*) *gravesiformis*, *O.* (*P.*) *Lamplughi*; *Astieria* (=Olcostephani of the group *O. Astieri*), *Olcostephanus* (*Astieria*) *sulcosus*; *Simbirskites* (=Olcostephani of the group *O. Decheni*); *Acanthoceras* (?) *peltoceroides*.

Arthur H. Foord.

II.—The Volcanic Rocks of Colombia.

W. Reiss and A. Stübel: Reisen in Süd-Amerika. Geologische Studien in der Republik Colombia. Part I. Petrographie. 1. Die Vulkanischen Gesteine. By Richard Küch. (Berlin, 1892. 4to. xiv.+204 pp. Nine Plates.

During the past ten years many important additions have been made to the knowledge of the volcanic rocks of the northern Andes, including contributions by Karsten, Bonney, Siemiradzki, Hettner, and Linck; a far more elaborate work has now been published giving the results of Dr. Küch's searching investigation of the large collection brought home by Drs. Reiss and Stübel from the expedition rendered famous by the important anthropological discoveries that attended their excavations at Ancon. The specimens of volcanic rocks alone number 1500, which are now preserved at the Museums of Berlin and Dresden, or in the collection of Dr. Reiss; some of them have been previously described, as the memoir of Carl Höpfner, issued in 1881, was based upon part of the material.

Dr. Reiss prefaces the work by a short introduction describing he main features in the relations of the Colombian Andes; at the orthern end of the country these form three distinct ranges, known s the eastern, central, and western Cordilleras. They are separated y the Magdalena and Cauca valley; to the south these contract ill finally the eastern range merges into the central chain. The wo lateral Cordilleras are composed of Cretaceous and Jurassic edimentary rocks, but the central chain is formed of old crystalline chists, gneisses, and Cretaceous eruptives. The difficulty in the tudy of the relations of these is increased by the fact that the ighest peaks are glacier clad.

Dr. Küch's description of the rocks is divided into two parts, general and a special. In the former the rocks are classified etrographically, and in the latter topographically; in this section reference map would have been of great assistance.

The rocks described are nearly all Andesites and Dacites, and the ork is mainly of value as giving a detailed study of these two roups, which are represented by very varied series, and a discussion f their relations. The author agrees with Rosenbusch in regarding he Dacites as entitled to rank as a distinct group, equivalent to that f the Andesites, and not as merely a type of the Amphibole or Mica Andesites. The Colombian volcanoes have yielded a very omplete series of representatives of the two groups, as the silica ercentage ranges from 54 per cent. to 78 per cent., so that all tages from felspar basalts to quartz trachytes are represented. Dr. Küch objects to Gümbel's classification into the two groups of he basaltic and trachytic types, and to Rosenbusch's classification f the dacites into the holocrystalline, felso-dacite, andesitic- and yalo-dacite. The arrangement which he proposes divides both ndesites and dacites into three groups; in the former the divisions re pyroxene-andesite, amphibole-pyroxene-andesite, and amphibole-ndesite; in the latter are the "biotite-amphibole-dacite, pyroxene-mphibole-dacite, and pyroxene-dacite. These divisions may be seful for the purposes of a petrographical description of cabinet pecimens, but they do not seem to be of value in the field, as the uthor points out that a transition may be traced from an augite-ndesite to an amphibole-andesite in a single hand specimen; he thus bjects to the view of Lagorio and Gümbel that these two types are harply separated from one another.

The pyroxene-andesite is the most important of the andesites and detailed description is given of the rock and its mineral constituents; among these, olivine and quartz are both present as ccessories. Pyroxene is usually represented both by monoclinic and rhombic species, usually augite and hypersthene. The plagioclase ranges from andesine to bytownite, as is shown by the specific gravity of isolated crystals, a method which the author has applied somewhat extensively.

The amphibole-pyroxene-andesite is intermediate between the other two types; in it a crystal of augite is often enclosed in one of amphibole and *vice versa*: in the pyroxene andesite the amphibole never encloses the *pyroxene*; the author thus concludes that in the latter the amphibole consolidated first, whereas in the amphibole-pyroxene-andesite the amphibole and pyroxene crystallized more or less simultaneously.

Amphibole-andesite is rare.

Among the Dacites the biotite-amphibole species is the most important. In this the felspar ranges between andesine and sanidine, and is often altered to opal. The most interesting part of the detailed description of this type is the discussion of the origin and significance of the so-called "corrosion-figures": he does not deny that crystals are sometimes corroded by the still fluid magma, but attributes many cases that would generally be attributed to this, to other influences, such as original deformations, oscillation, twins, mechanical strains, etc. A spherulitic structure, though of a somewhat imperfect type, occurs in this rock and in the pyroxene andesite. In the pyroxene-amphibole andesites, andesine is the chief plagioclase, while basaltic olivine is present as an accessory. Pyroxene-dacite was only once met with.

The last section of the "General Part" is devoted to the segregations, agglomerate-lavas, and ejected blocks and ashes. A felspar basalt is represented by specimens from three localities. A chapter is also devoted to the evidence afforded by 17 analyses, as to the chemical relations of andesite and dacite; the silicate percentage of the former ranges from 54·21 to 62·26 per cent.; and that of the latter from 63·36 to 70·22 per cent.

The "Special Part" dealing with the geographical distribution of rocks, occupies from pp. 89–192; the most interesting point brought out in this is the great variation of the rocks at each volcanic centre: thus andesites and dacites are associated, and usually in more than one variety of each.

The description of rock-specimens considered apart from their field relations is never of course the ideal method of petrography, as no doubt Dr. Küch would be quite ready to admit; but in the case of such distant and comparatively inaccessible areas as the Republic of Colombia, it is all that can be hoped for at present. The detailed descriptions of the rocks, however, will greatly lighten the labours of the lucky geologist to whose lot it may fall to work out their relations in the field. We must accordingly be grateful to Dr. Küch for the care with which he has investigated the materials, and to the two illustrious travellers whose careful collecting has added so greatly to our knowledge of the geology of the northern Andes. J. W. G.

III.—The Muir Glacier.

"Studies of the Muir Glacier, Alaska. By Harry Fielding Reid. National Geographic Magazine, Vol. IV., pp. 19–84, pls. i.–xvi. Washington, D. C., 1892.

THE exploration of Alaska is being rapidly advanced by the energy of the American geographers and geologists. The latest addition is a detailed study of the Muir Glacier, made last year by Professor Reid, and which has resulted in the correction of some very important errors in our previous knowledge of the district. The principal measurements of the glacier as given by Professor Reid's survey are a length of 35 miles, a width varying from 6 to 10 miles and an area of 350 square miles. The thickness is 900 feet at the seaward end, and is much less than had been stated. The glacier slopes upward at 1° 15′ towards the nevé fields; the mountains around the glacier are from 5,000 to 7,000 ft. in height. The glacier is now receding very rapidly, and has retreated 1,000 yards in four years, a rate which far surpasses that ever attained by the Rosenlaui Glacier; its greatest extent was reached about 150–200 years ago. Around the fiord there is plenty of evidence of submerged forests, and Professor Reid therefore suggests that the diminution in the ice has been due to subsidence. The ablation is at the rate of 2 ins. a day, a measurement of much interest as reliable estimates for the Alaskan glaciers have been so far wanting. One of the most important parts of Professor Reid's work was his measurement of the rate of motion; this was calculated by Professor Wright at 70 ft. a day. Professor Reid's careful observations, however, show that this was enormously exaggerated, and that the very highest speed is 7 ft. 2 ins. a day. In a line across the glacier, a little above its mouth, the average daily motion was as follows: 4 ins., 2½ ft., 5¾ ft., 6½ ft., 4 ft. 8 ins., 6 ft. 1 in., 7 ft. 1 in., 7 ft. 2 ins., 6 ft. 2 ins., 4 ft. 9 ins., and 7 ins. The estimate of the amount of erosion that the glacier effects on its rock bed is also of interest. Professor Reid estimates that it amounts to as much as three-quarters of an inch per annum. The paper is illustrated by a series of photographs, which, though many of them are greatly over exposed, admirably depict the principal features of the greatest of the glaciers on the American mainland. J. W. G.

CORRESPONDENCE.

SHAPES OF SAND GRAINS. FLEXIBLE SANDSTONE.

Sir,—Mr. T. Mellard Reade in his interesting article on "Glacial Geology," in the July Number of the Geological Magazine refers —page 314—to the evidence afforded by the shapes of sand-grains in enabling us to determine the marine or fresh-water character of the deposit of which they form a part. As I have devoted many years to the study of Sands, perhaps I may be permitted to make a few remarks upon the subject.

Like Mr. Mellard Reade, I have examined Sands from many parts of the world, and I can endorse his views respecting the (generally) more-rounded appearance of marine sands than river-borne sands. I have found, however, that nearly all river-borne sands have a large percentage of *cylindrical* and *tabular* grains, while in wave-borne sands (remote from rivers) the percentage of such grains is very small. I have frequently explained what I believe to be the cause of this, and thence the value of the fact in enabling one to distinguish between those sands deposited by rivers, and those deposited by waves.

Mr. Mellard Reade states that "Blown-sand of sand-dunes is not distinguishably more worn than the sand of the shore from which it is derived." I do not know what particular dunes are referred to, but I must say that my experience is quite the reverse of this. Blown-sands of deserts and dunes procured from many parts of the world have never yet failed to provide me with characteristically-rounded grains in great abundance.

Of course much will depend on the particular spot from whence samples are procured. Grains freshly blown up from the shore on to the surfaces of dunes would not become appreciably rounded until they had travelled some distance inland, and had been whirled about in hollows and depressions for some length of time. The places to find rounded grains of blown-sand would be, therefore, in such depressions some distance from the shore, and I feel sure that anyone collecting samples from such spots will confirm my opinion. It must be clear that the action of the wind *in time*, by hurling the grains one against the other, would produce (in the case of quartz) sphericity through abrasion, and numerous sands prove this.

A fact that does not appear to be known in connection with grains of blown-sands is that many of the grains exhibit the *mastoid* markings so frequently seen on flint pebbles, and these markings clearly show with what force the grains have collided. I have never found these markings on wave-borne sand grains, simply because in the denser medium—water—the grains do not collide with sufficient force to enable them to become developed. Some years ago, at St. Agnes, in Cornwall, I found a deposit of white quartzose sand (probably Pliocene), the larger grains of which were covered with these markings, and these alone, I considered, pointed to the Eolian character of the deposit.

Before we can base any conclusion—as to the *locating agent* of a particular deposit—upon the rotundity of certain sand-grains contained therein, we must satisfy ourselves that such grains were not already rounded and polished in the parent rock from which they were derived.

In reference to Mr. Pittman's letter on "Flexible Sandstone," it does not appear to have been noticed that nearly thirty years ago Dr. Wetherell published an opinion that the flexibility was due to the grains being "arranged in definite groups separated from one another by intervening cavities." CECIL CARUS-WILSON.

BOURNEMOUTH, *July* 11, 1892.

SUBTERRANEAN EROSION OF THE GLACIAL DRIFT, A PROBABLE CAUSE OF SUBMERGED PEAT AND FOREST-BEDS.

SIR,—In December last a paper under this title was read before the Geological Society by Mr. William Shone, F.G.S., and more recently a *resumé* of it was given to the Chester Natural Science Society. The author described a section at Upton, near Chester, cut by two streamlets through Boulder-clay resting on a considerable thickness of sand. The clay sloped towards the sides of the streams, and Mr. Shone stated that the percolation of water along the sand, towards the streamlets, had caused a subsidence of the clay to the amount of thirty feet. Not having seen the section I can give no definite opinion upon it, but in the paper referred to Mr. Shone endeavours to explain the subsidence of the Peat and Forest-beds at Ince, on the south shore of the Mersey, and on the west coast of England, as having been caused by the subterranean erosion or denudation of the underlying beds.

Mr. Shone gives the section of the Peat and Forest-beds from Ellesmere Port to Ince Ferry from my recently published "Geology of the Country around Liverpool," and assumes that the four basin-like depressions along the Manchester Ship Canal were caused by subterranean erosion and not by the deposition of silt and the growth of peat between ridges of sandstone. I do not, however, see that this theory can be satisfactorily applied to the post-Glacial beds referred to, for all the conditions are very different to those at Upton. It does not seem to be a logical conclusion to assume that because subterranean erosion occurs at Upton in consequence of a bed of sand underlying the Boulder-clay that it also occurs at Ince, in consequence of beds of grey silt and stiff clay underlying the Peat and Forest-beds. Mr. Shone refers to a bed of sand between the Boulder-clay and the post-Glacial beds at Ince; but it is quite a local deposit and changes to a grey clay within about 100 yards, and there is no such sand at Stanlow and Ellesmere, where the same amount of subsidence is shown. It does not seem possible that the beds of stiff clay could have been eroded beneath the surface under an area of several square miles of country, not only about Ince, but in other similar areas near Liverpool.

Mr. Shone's theory is, however, not original in connection with the district, for in 1854 the late Mr. John Cunningham, F.G.S., brought it before the British Association, and, so recently as 1887, in a paper read before the Liverpool Geological Society, and published in the Proceedings, on the "Stanlow, Ince, and Frodsham Marshes," I attributed the sinking of the land for about fifty yards along the edge of the Marshes to the influence of water from the river on a bed of sand underlying the grey clay and Peat and Forest-beds, but I afterwards found that the sand was not persistent, and that the slope of the land towards the Mersey was probably the original form of the ground. According to Mr. Shone's theory the surface of the land should fall rapidly along the edge of the Gowy and other streams, but I have seen no such subsidence.

Several instances have been described where the Peat and Forest-beds occurred on the Bunter Sandstone, many feet below the range of the tides. About Ince these beds rest on the rock in many places, and at various elevations. Along the shore on the north of the line of section the Peat and Forest-bed, with the trunks of trees, was seen resting on the Boulder-clay, and at the distance of a few yards on the rock.

The Boulder-clay rests on sand in cliff sections in many places around Liverpool, but I have never seen such an instance of subsidence caused by subterranean erosion as that described by

Mr. Shone. Possibly I may have overlooked some similar section, but I do not remember reading of any such subsidence in older formations. It is very remarkable that such an active agent has not been observed in the Tertiary formations of the South of England, where the beds of clay and sand are similar, and occur under the same conditions. G. H. Morton.

209, Edge Lane, Liverpool.
July 16th, 1892.

"CONE-IN-CONE" STRUCTURE.

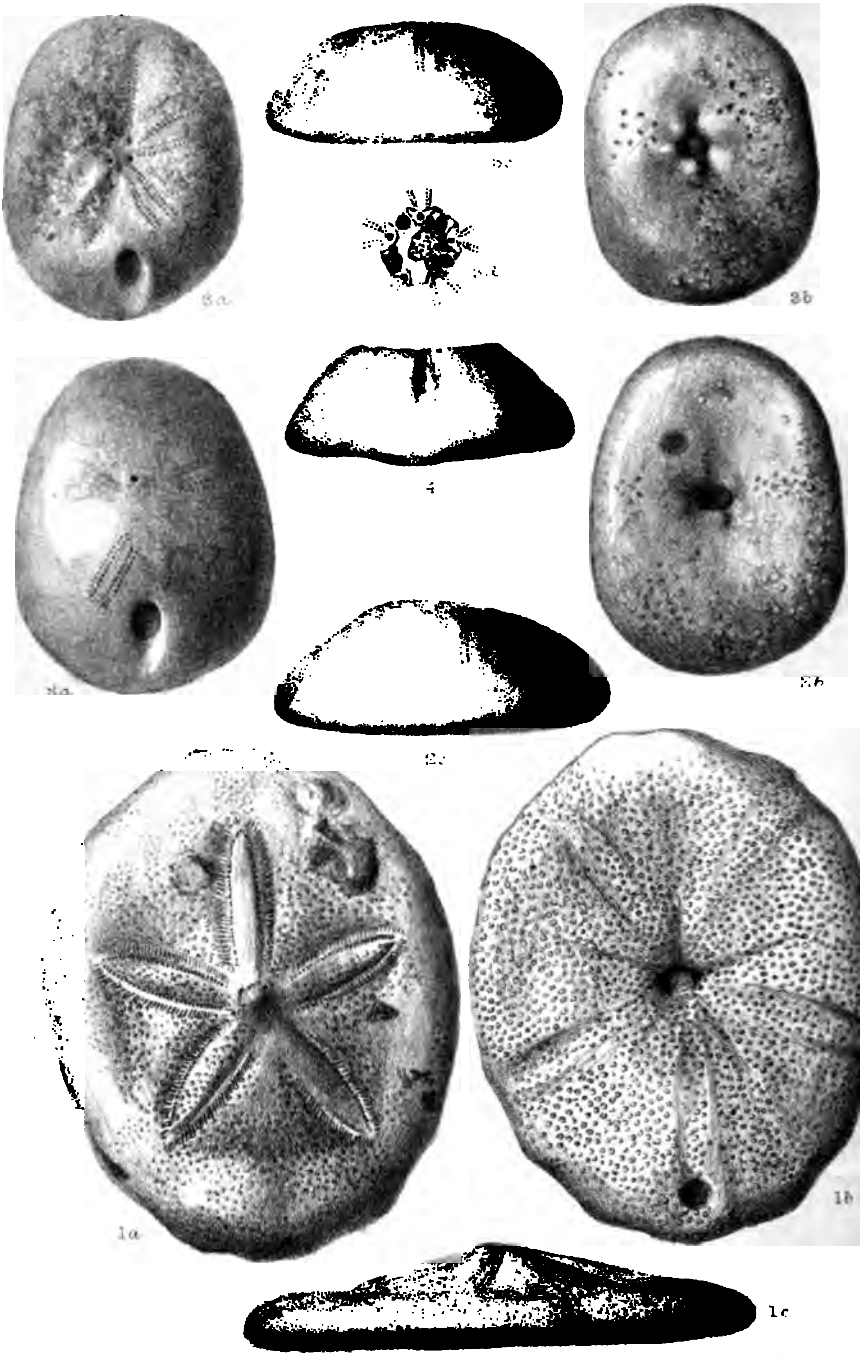
Sir,—Observing that the "Cone-in-Cone" controversy still goes on in the Geological Magazine, I beg you will permit me to remark in this connection, that the question whether this puzzling formation occurs on both sides of slabs and nodular masses of calcareous rocks, clay-ironstone, etc., *i.e.* whether the apices of the layers of cones point upwards as well as downwards or not, was set at rest long since, at all events to *my* entire satisfaction [See Geol. Mag. for January, 1887, p. 17]. It seems to me that Fig. 5 therein entirely upsets Mr. Jno. Young's theory of how this rock was formed.

Since I resided in U.S.A. my attention has repeatedly been called to double cone-in-cone (one layer over another, with the cones set in opposite directions) occurring in a certain bed of limestone in the Lower Productive Coal-measures of Western Pennsylvania, as well as in the Portage-beds of the Devonian series, upon which the place I write from is built; but as yet I have not had an opportunity of demonstrating that the said *double cone-in-cone* exists, by making a photograph of same *in situ*, which I mean to do as soon as possible, and send you a copy of. I may, however, say here, that this variety of cone-rock occurs both in flat irregular-shaped nodules or cakes, and also in beds, whenever or generally when the limestone-bed it runs in thins down to only a few inches. I do not imagine that the cone-in-cone *coal*, spoken of by Mr. Garwood in this month's Geol Mag. (July, 1892, p. 334) can be of similar origin to that so often seen in clay-ironstones, limestones, etc. I think Mr. Garwood's cone-formation in coal is what miners sometimes call "cockscomb coal;" a structure commonly met with in the smokeless coal-beds of Glamorganshire, and more rarely in anthracite in Pembrokeshire. The "Hard mine" seam of N. Staffordshire sometimes exhibits a somewhat similar fracture, and I once detected cone-coal in the ordinary pit-coal (bituminous) of the "main" seam in Leicestershire. It runs in the semi-bituminous coals of Liege, Belgium. I look at it in coal as a kind of crystallization.

Erie, Penna., U.S.A., W. S. Gresley, F.G.S.
14th July, 1892.

MISCELLANEOUS.

We have much pleasure in announcing that the Queen has been pleased to approve of the following promotion in the Most Honourable Order of the Bath (Civil Division); to be K.C.B., Professor William Henry Flower, C.B., F.R.S., Director of the British Museum (Natural History), Cromwell Road, S.W.



rd del et lith

West,Newma

Australian Fossil Echinoidea.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IX.

No. X.—OCTOBER, 1892.

ORIGINAL ARTICLES.

I.—FURTHER ADDITIONS TO AUSTRALIAN FOSSIL ECHINOIDEA.

By J. W. GREGORY, B.Sc., F.G.S.;
of the British Museum (Natural History).

(PLATE XII.)

DURING the last two years four papers have appeared upon the Australian Cainozoic Echinoids, contributed by M. Cotteau,[1] Prof. R. Tate,[2] Herr A. Bittner,[3] and myself.[4] These add considerably to our knowledge of the fauna; they show that it is Eocene and Oligocene, instead of Miocene, and that it is remarkably varied and rich in genera. I am now able to add one or two more species to the list, and at the same time take the opportunity of referring to one or two changes proposed by Prof. Tate and Herr Bittner.

Fam. LAGANIDÆ.

Genus, *Laganum*, Gray, 1825.

J. E. Gray. "An attempt to divide the Echinida. . . . ." Ann. Phil. 1825, vol. x. p. 428.

Species, *Laganum decagonale*, Lesson. Var. *rictum*,[5] n. var. Pl. XII. Fig. 1.

SYNONYMY (of the species). See A. Agassiz. Revision of Echinoids. Illus. Cat. Mus. Comp. Zool. No. 7, 1872, p. 148.

Scutella decagonalis, Lesson, 1827, in Poiret. Scutello Dict. Sci. Nat. t. xlviii. p. 229.

Lagana decagona, Lesson, 1834, in Blainville Actinologie, p. 215, pl. xviii. fig. 3.

Laganum decagonum, Lesson. L. Agassiz. Mon. Echinod. ii. Scutelles, 1841, p. 112, pl. xxiii. figs. 16–20.

DIAGNOSIS (of the variety).

Form: elongated elliptic; the posterior end is longer and narrower than the anterior; the anterior end is semicircular; the sides taper backward. The base is flat; the margins are tumid, and are separated from the slightly conical apex by either a flat platform or a slight broad depression.

---

[1] G. Cotteau. Echinides nouvelles ou peu connues. No. IX. Mém. Soc. Zool. France, t. iii. 1890, pp. 546–550, pl. xii. figs. 13–18. No. X. *Ibid.* t. iv. 1891, pp. 629–630, pl. xix. figs. 10–14.

[2] R. Tate. A Bibliography and revised list of the described Echinoids of the Australian Eocene, with descriptions of some new species. Trans. Roy. Soc. South Australia, vol. xiv. pt. 2, 1891, pp. 270–282.

[3] A. Bittner. Ueber Echiniden des Tertiärs von Australien. Sitz. k. Ak. Wiss. Wien, Bd. CI. Abt. i. 1892, pp. 331–371.

[4] J. W. Gregory. Some Additions to the Australian Tertiary Echinoidea. GEOL. MAG. Dec. III. Vol. VII. 1890, pp. 481–492, Pls. XIII.–XIV.

[5] From *ringor*, *rictus*, to open the mouth widely.

Ambulacra: Petals extend two-thirds of the distance from the apex to the ambitus; the lateral pairs are equal in length; the anterior ambulacrum is the longest. The petals are sharply closed below; the width of the pore area expands rather gradually to the distal end of the petal, then is there closed somewhat abruptly. The interporiferous areas are large, and taper slightly to the blunt distal end.

Apical system: at the apex of the test. The madreporite is raised, large, and central. There are four large genital pores. Of the radial (ocular) pores the right antero-lateral is very large; those of the right postero-lateral and left antero-lateral ambulacra are small; the left postero-lateral pore is not developed.

Peristome: mouth somewhat pentagonal; large; the width is half as much again as the length. It is situated before the centre. There are no interradial actinal furrows.

Periproct: the anus is large and almost circular; it is close to the margin.

DIMENSIONS.

Length			68	millimètres.
Width			55	,,
Height			12	,,
Mouth:	width		6	,,
	length		4	,,
	distance from anterior margin		31	,,
Apical system:	distance from anterior margin		31	,,
Petals:	anterior:	length	22	,,
		width	6	,,
	antero-lateral:	length	20	,,
		width	6	,,
	postero-lateral:	length	20	,,
		width	6	,,

DISTRIBUTION.—Cainozoic. Shark's Bay, West Australia.

Collected by HARRY PAGE WOODWARD, Esq., F.G.S.

AFFINITIES AND DIFFERENCES.—The specimen on which this species is founded is unquestionably a very close ally of *Laganum decagonale*, Less., though, as to whether it should be regarded as a variety or a distinct species, I do not care to express an opinion on a single specimen. It differs from that species by the elliptical and somewhat pentagonal shape of the mouth, and the absence of the five interradial furrows which radiate from the mouth. The British Museum contains a large series of specimens of that species, but the circular form of the mouth is constant; the actinal depressions do vary in degree of development, but I have not seen one in which it is not quite distinct. These two characters may not improbably be of specific value.

The shape of the test differs from the normal decagonal form; but some specimens of the species have a form identical with the fossil.

Herklots figured[1] a specimen from the Java Tertiaries as *Scutella decagona*, n. sp., Martin[2] referred this to *Peronella decagonalis*, Ag., and included *L. angulosum*, Herklots,[1] as a synonym; but as Herklots neither figured nor described the actinal side, a certain amount of doubt must remain as to the accuracy of this determination. As the present variety differs from the previously known species in the same points as *L. decagonalis*, it need not be compared more closely with them.

---

[1] J. A. Herklots. Fossiles de Java. Pt. IV. Echinodermes. Leyden, 1854, p. 9, pl. i. figs. 6, 6*a*.

[2] K. Martin. Die Tertiärschichten auf Java. Anhang. Revision der von Herklots herausgegebenen fossilen Echinidens Java. Leyden, 1880, p. 3.

Family, CASSIDULIDÆ.

Genus, *Cassidulus*, Lamarck, 1801.

Système des Animaux sans Vertèbres. 1801. p. 348.

Species, *Cassidulus florescens*, n. sp. Pl. XII. Figs. 2–4.

Floresco, to begin to blossom, referring to the imperfectly developed floscelle.

DIAGNOSIS.—Outline seen from above elongated, tapering to the anterior end; the greatest width is at the distal end of the postero-lateral petals. The margins are long and fairly straight. The ends are well rounded. Seen from the side it appears evenly rounded, except for the flattened posterior slope. The ambitus is tumid.

The actinal surface is concave; the peristome occurs at the summit of the depression. The median bare band is imperfectly developed.

Apical system: before the vertex. A large central madreporite and four genital pores.

Ambulacra: Petals sublanceolate, flush; open below. The anterior is the longest. The antero-lateral pair is considerably shorter than the postero-lateral pair.

Peristome: anterior. Floscelle not well developed; the bourrelets are massive, but not prominent. Mouth pentagonal.

Anus oval: broad and large. The subanal groove shallow, short and broad.

DIMENSIONS.

Length	22 mm.	19·5
Width: at apical system	16 ,,	14·5
maximum...	17 ,,	15·5
Height	9 ,,	8
Distance of apical system from anterior end ...	9 ,,	8
,, vertex ,, ,, ...	11 ,,	10
,, mouth ,, ,, ...	10 ,,	9

DISTRIBUTION.—Fyans Ford Hill, Moorabool River; 1½ miles N.W. of Geelong. Middle Murravian. (Upper Eocene.)

TYPE.—Brit. Mus. E. Presented by T. W. Reader, Esq., F.G.S.

AFFINITIES AND DIFFERENCES.—This species is most clearly allied to the Lutetian (Upper Eocene) *Cassidulus faba*, Defr.[2] The most important difference between them is in the structure of the petals: these are longer and almost entirely closed in the French species, whereas in the Australian form they are almost open; the anus is also longer and narrower and the test higher. Its shape resembles that of *Echinobrissus vincentinus*, Tate, but there is no reason to doubt the accuracy of Prof. Tate's generic determination.[3]

---

[1] J. A. Herklots, *op. cit.* p. 8, pl. ii. fig. 4.

[2] Defrance Dict. Sci. Nat. t. vii. 1817, p. 227. For figures and synonymy see Cotteau, Pal. Franç, Echinides Eocènes, t. i. 1887, pp. 510–512, pl. 139.

[3] Tate, *op. cit.* p. 280.

As the species is associated at Fyan's Ford with *Sarsella forbesi* (Woods and Dunc.) *Monostychia australis*, Laube, and a specimen which is probably a young *Cassidulus* (*Australanthus*) *longianus*, Greg., there can be no doubt of its age.

The reference to the last named species necessitates the consideration of the genus *Australanthus* recently founded by Herr Bittner for an Australian species described in 1890 as *Cassidulus longianus*. Herr Bittner regards his genus as apparently most allied to *Hardouinia*, and as intermediate between *Cassidulus* and *Breynella* (*Echinanthus*, Desor *non* Leske). In 1890 I followed Desor in not accepting *Hardouinia*; and as I regarded the new species as occupying the same position in relation to *Cassidulus* as d'Archiac and Haime's genus held to *Echinanthus*, it did not seem desirable to found a new genus for the species. The late Prof. Duncan, however, finally accepted *Hardouinia* as a sub-genus, and as it is also adopted by M. Cotteau and Herr Bittner, the current opinion is strongly in its favour. As *Breynella* is a large genus, there is much to be said on the grounds of convenience for any sub-genera that are based on characters that are at all satisfactory. The acceptance of *Hardouinia* necessitates the adoption of *Australanthus*. Herr Bittner seems to ally it most closely to *Hardouinia*. I am, however, still inclined to consider it as nearly related to *Cassidulus*, with which it agrees in its ethmolysian, or almost ethmolysian apical system, in the characters of the tuberculation of the actinal surface, in the subpetaloid ambulacra, and in the forward position of the anus. These seem more important characters than the large size of the species, and the depression of the peristome. Herr Bittner suggests that the division may be only sub-generic, and as a sub-genus of *Cassidulus* I propose to adopt it.

Fam. SPATANGIDÆ.

Schizaster, sp.

Mr. H. P. Woodward's collection from Champion's Bay includes an internal cast of an Echinoid which is in all probability a *Schizaster*. In the absence, however, of any knowledge in regard to the fascioles, the generic position cannot be determined. Mr. Woodward[1] quotes the genus *Brissus* as occurring at Shark's Bay; otherwise this is the only Spatangoid from Western Australia.

Macropneustes decipiens (Tate).

That the Spatangoidea will always be grouped mainly by the arrangement of the fascioles is not at present likely to be questioned; but it is attended with the disadvantange that when species are described from but one or two specimens, their true generic position is very likely to be uncertain. Thus the species now known as *Sarsella forbesi* (Woodw. and Dunc.) thrice changed genus owing to better specimens demonstrating the presence of fascioles not shown in those previously described. In Prof. Tate's admirable Bibliography and Revised List of Australian Echinoids, he has shown that a similar change must be made in the position of a species which I referred to *Pericosmus compressus* (Duncan). He removes the specimen figured to *Eupatagus* on the ground of the tubercles on the abactinal surface; but this alone would be insufficient to necessitate its removal. I have, however, worked away the matrix covering the subanal area of the type-specimen, a risk to which I did not previously care to subject it. This shows that a subanal fasciole is present; the species must therefore be removed from the Prymnadete to the Prymnadesmian group. But in *Eupatagus* the species has not reached its final resting place, for in that genus the petals of the paired ambulacra are broad and flush, with large poriferous zones: in this species they are long, narrow, and depressed, and the pores are small, and not so strikingly dissimilar in size. It therefore belongs to the genus *Macropneustes*, which Prof. Duncan regarded as only a sub-genus of *Eupatagus*,[1] but which most authors keep as a quite distinct genus. The synonymy of this species will therefore be:

---

[1] H. P. Woodward, Western Australia, Annual General Report for 1890, p. 14. (Perth, 1891.)

Pericosmus compressus, Dunc. *non* M'Coy. Gregory, Geol. Mag. 1890, p. 485, Pl. XIV. Fig. 1.
Eupatagus decipiens, Tate. Trans. Roy. Soc. S. Australia, vol. xiv. p. 282.
Macropneustes decipiens, Tate. Gregory.

DESCRIPTION OF PLATE XII.

Fig. 1.—*Laganum decagonale* (Less.) var. *rictum*, n. var. Shark's Bay, W. Australia. Figs. 1*a*. Abactinal side; 1*b*. Actinal side; 1*c*. Lateral view. Nat. size.

Figs. 2, 3 and 4.—*Cassidulus florescens*, n. sp. Middle Murravian. Fyan's Ford, near Geelong. Figs. 2*a*. Abactinal side; 2*b*. Actinal side; 2*c*. Lateral view: each × 2 dia.

Fig. 3*a*.—Abactinal side; 3*b*. Actinal side; 3*c*. Lateral view; 3*d*. Apical system: × 4 dia. Fig. 4.—Posterior view of another specimen: × 2 dia.

II.—On Liassic Sections near Bridport, Dorsetshire.

By John Francis Walker, M.A., F.G.S.

During my visits to West Bay, Bridport, in the years 1887 and 1888, I was able to examine the following inland sections of the Lias Junction Bed, and I communicated a paper to the British Association at Leeds in 1890; an abstract of this paper appeared in the Report. I had hoped to obtain more evidence of the nature of this deposit, but, unfortunately, last year, 1891, I found that the working of the Allington brickfield was being abandoned, and that it was difficult to further work the roadside cuttings without doing considerable damage. I therefore think it better to lay before the readers of the Geological Magazine my notes on this deposit, which I shall be able to show is variable in different sections, due to the amount of denudation which has taken place.

Several notices of the Junction bed have been written, but chiefly with reference to the sea-coast section. I will only refer to those required for discussion in this paper.

In the Quarterly Journal of the Geological Society, 1863, Mr. Day gave an account of the junction bed of the Upper and Middle

---

[1] M. Cotteau has recently given admirable figures of the type species *Macropneustes deshayesi*, Ag., Pal. Franç. Echinides Eocènes, pl. xxxi–xxxiii.

Lias on the sea-coast of Dorset. He describes it as "a remarkable band of stone, the lower part of which is in a great part a conglomerate, the pebbles being imbedded in a more or less ferruginous matrix with Oolitic granules." "In places, however, this bed assumes more the appearance of the Marlstone of other districts." The higher part is composed of thin beds of a hard, dense, almost chert-like, limestone, separated by thin laminæ of yellow ochreous clay, the whole being consolidated into one block; he states the thickness of the Marlstone and Limestone to be from two to three feet; that *Ammonites serpentinum* (*falciferum*) occurs in the lower part of the Upper Lias Limestone in some abundance, though badly preserved, and considers denudation of that bed had taken place.

This junction bed is also well described by H. B. Woodward, in his valuable work on "The Geology of England and Wales," "as a pink and cream-coloured limestone in the upper part, and a brown nodular marlstone below." Mr. S. S. Buckman, in a paper (Quart. Journ. Geol. Soc. 1890), refers to this rock, and states the limestone of the fallen blocks is in two layers, *Hildoceras bifrons* being dominant in the upper layer, and *Harpoceras falciferum* in the lower.

I have very little to add to these remarks on the sea-coast section, except that I have found blocks of the limestone four feet thick, generally cream-coloured in the upper and pink in the lower part, and that the sandy part is sometimes a conglomerate, and at other times a marlstone, as pointed out by Mr. Day. Blocks of this stone were collected from Down Cliffs and under Thorncombe Beacon, and used for building walls at Chideock, hence the fossils in old collections are labelled from Chideock.

The following are the Inland Sections which I have examined:—

I.—The roadside cutting at North Allington below the brickfield (1887):

			ft.	in.
A.		Clay, worked as a brickfield.		
B.	(1)	White limestone	0	8
	(2)	Clay	0	1
	(3)	Brown and red limestone	0	11
	(4)	Marlstone	0	8
C.		Sandy Clay	3	2
D.		Brown sandy limestone, blue in centre	0	5
E.		About two yards of sandy marl, partly covered with grass and roadside scrapings	6	0
F.		Brown friable sandstone	2	1

From the brickfield I obtained a block of stone, probably from the next stone band, which contained *Monotis inæquivalvis* and *Rhynchonella amalthei*.

The fossils which I have been able to determine from bed D are:

Rhynchonella tetrahedra, var. *Northamptonensis*.
Rhynchonella furcillata.
Waldheimia (*Zeilleria*) *perforata*, var.
Spiriferina pinguis.
Monotis inæquivalvis.
Pecten, sp.
Plicatula spinosa.
Pholodomya ambigua.
Pleuromya costata.
Belemnites paxillosus.

About one foot of the clay above this stone band contained the same fossils, and others which were too imperfect to name.

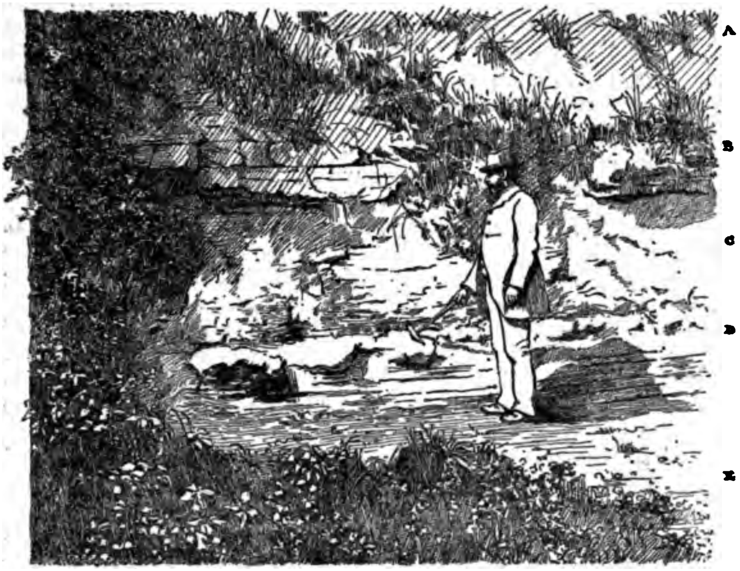
This bed, D, probably belongs to the upper part of the Margaritatus zone.

It was impossible to work the pink and white rocks without destroying the bank on the roadside. I was unable to obtain any fossils from the brick-clay, although I told the workmen to search for them.

The chief interest of this section is that it shows a division in the stone band, and the position of the stone band D, which contains fossils that correspond to those found on the beach in a bed of brown sandy limestone.

II. In the field opposite, which was formerly worked as a brick-field, about 15 feet of brick-clay having been removed, the following section was exposed in 1888:

			ft.	in.
A.	1.	Surface soil	0	6
	2.	Clay	2	10
	3.	Ferruginous marl	0	3
B.	1.	Hard limestone	1	2
	2.	Marlstone	0	6
C.		Sandy clay	0	6



Section at North Allington.

(From a photograph by Mrs. E. Penton.)

I obtained the following fossils from the loose blocks of marlstone:

Rhynchonella tetrahedra.
—— *serrata.*
—— *egretta*, var.
Terebratula punctata.
Spiriferina rostrata.
Lima, sp.
Pleuromya costata.
Cryptænia expansa.
Belemnites paxillosus.

From the lower part of the hard limestone:

Rhynchonella Bouchardi.
Waldheimia Lycetti
Ammonites (*Hildoceras*) *bifrons.*
Ammonites (*Harpoceras*) *falciferum.*

And from the Upper part *Ammonites* (*Harpoceras*) *striatulum*. Mr. H. B. Woodward also records the occurrence of this Ammonite at Allington. It will be observed that the thickness of the bed B, including the marlstone, is only 1 foot 8 inches; in the section on the other side of the road it was 2 feet 4 inches, but the bed was probably thicker in some parts of this field, as I was informed that large quantities of stone were formerly obtained from it. The Marlstone fossils in this quarry were not found mixed with Upper Lias species in the same blocks of stone.

There is an indication of the presence of the Jurense zone in the upper part of the stone band.

Some peculiar forms of Brachiopoda occur in this quarry which require careful study.

III.—A deep cutting in Shoots Lane, Symondsbury, which was overgrown with vegetation, appeared to show the following sections:

	ft.	in.
(1) Sandy clay, overgrown, about...	10	0
(2) Dark ferruginous rock containing nodules and worn small specimens of *Ammonites* (*Hildoceras*) *bifrons*	0	5
(3) Light coloured stone	1	2
(4) Stone band (in three divisions)	1	6
(5) Marlstone	2	11
(6) Soft brown sandy stone	0	4
(7) Clay	0	6
(8) Overgrown	3	4

This section was again carefully measured by the Rev. J. L. Templer and myself in 1891. The chief peculiarities are—the occurrences of a conglomerate bed above the junction bed containing worn specimens of *Hildoceras bifrons*. Mr. S. S. Buckman kindly examined these specimens and agreed with my determination of them; this indicates that while this bed was being deposited in this section, denudation of the bifrons zone was taking place elsewhere. The junction bed appears to be represented by the three stone bands.

The marlstone contains *Rhynchonella serrata* in its upper, and *Rhynchonella tetrahedra* in its lowest part. Should this lane ever have to be widened no doubt many fossils will be found.

IV.—In the year 1887, the supply of stone from the Forest Marble having fallen short, a hole was made on the roadside of Shipton Long Lane, Bothenhampton, for road metal; unfortunately the police ordered this hole to be filled up before it had time to weather. It was about 5½ yds. long, 3 yds. wide, and 6½ ft. deep, which is equal to between 30 and 40 cubic yards of solid stone. It was all in one block and required 11 lbs. of gunpowder to blast it. From information obtained from the workman, by measurement of the blocks and many days' work at breaking them and carefully collecting the fossils, the following appeared to have been the section:—

		ft.	in.
(1)	Unfossiliferous sandstone, about	0	4
(2)	Top band of white stone	1	0
(3)	Brown stone	1	0
(4)	Brown conglomerate often with pink stone at the base	2	0
(5)	Marlstone	1	0
(6)	Blue unfossiliferous limestone	0	8

The above may be regarded as the average thickness of the bed.

The *blue limestone*, which the workman said was the base of the rock, was coated on its lower surface with calcite, and rested on sand.

The *Marlstone* was of the usual brown colour, becoming yellow and more friable in some blocks, but towards its upper part was redder, and appeared in many blocks to gradually pass into the pink limestone which generally occurred at the base of the conglomerate; the pink rock appeared to have been slowly deposited on the surface of the marlstone.

The *Conglomerate* bed varied in colour, being mostly brown, differing from the marlstone in being harder and of a lighter colour; in some parts it had a greenish tint; its lower part was a pink rock with Oolitic grains, in the upper part it contained nodules, and some of the blocks were perforated by boring shells. Above this was a light brown stone which joined the hard cream-coloured stone. The top bed was an unfossiliferous sandstone which reached the surface of the road.

The fossils, especially the Brachiopoda, were carefully collected by breaking the blocks; after a few days' work we were able to sort the blocks, and to tell what species they would contain. No specimens of Vertebrata were obtained. Many specimens of Gasteropoda were found, but owing to the hardness of the rock it was impossible to extract them entire. It also contained several species of *Pecten*, *Lima*, etc.

The Marlstone contained in its lower part:

Spiriferina rostrata.
Rhynchonella tetrahedra, Sow.
——— *egretta* ? E. Desl.
Terebratula punctata, Sow.
——— sp. (*T. Jauberti*) ? E. Desl.
——— *Edwardsii*, Dav.
Waldheimia (*Aulacothyris*) *resupinata*, Sow.
——— (*Aulacothyris*) *Moorei*, Desl.
——— (*Zeilleria*) *indentata*, var. Sow.
——— (*Zeilleria*), sp.
——— *subnumismalis*, Dav.

Along with *Ammonites* (*Amaltheus*) *spinatus.*

In the upper part of the Marlstone *Rhychonella serrata*, Sow.

Remarks.—It will be noticed that *Rhyn. serrata* occurs in the upper part of the Marlstone. It is stated by Mr. C. Moore to occupy the same position near Ilminster; this species, generally a rare fossil, was very abundant. I obtained nearly 200 specimens, more or less perfect, in a bed about three inches thick. It will be remembered that the area of the pit was about seventeen square yards. Some varieties of *Rhyn. serrata* show that it is related to *Rhyn. quinqueplicata*, Quenstedt.

Rhynchonella tetrahedra was not common, and was a fine ribbed variety.

Rhynchonella egretta ? This species is referred by Davidson in his Ool. Suppt. to *Rhyn. egretta*; but some specimens closely resemble E. Deslongchamp's figure of *Rhynchonella fallax*: it will have to be compared with the French specimens, which are very difficult to obtain; it is a very variable form.

Mr. Day gives *Rhynchonella acuta* from the Down cliffs, where I have also found it. I did not see a fragment of it in this section. There is a remarkable form of *Terebratula*, of which I obtained three perfect specimens, probably a variety of *T. Jauberti*, E. Desl.

Waldheimia (*Aulacothyris*) *resupinata* does not appear to have been found by Mr. Day, as he states it is altogether absent in the sea-coast section. It is rare at Bothenhampton; I only obtained eight specimens, two of which were imperfect; it agrees with the South Petherton form.

Waldheimia (Aulacothyris) Moorei, one typical specimen.

Waldheimia (Zeilleria) indentata, rare, a wide variety.

Waldheimia (Zeilleria) sp, this may be new, it is nearest to *W. scalprata*, Quenstedt. It is a small triangular form belonging to the *W. Waterhousei* and *W digona* group.

Waldheimia (Zeilleria) subnumismalis, rare, and not so fine as those of the coast section.

The *Conglomerate bed*, in its lower part, contained in some blocks large quantities of a *Belemnite* probably *B. paxillosus;* also worn specimens of *Ammonites* (*Harpoceras*) *falciferum*. But in many blocks the pink stone rested upon the *Rhynchonella serrata* bed, the Ammonites, which occurred very abundantly, were *Ammonites* (*Hildoceras*) *bifrons;* they are fine, large, and very well preserved specimens, although difficult to extract on account of the hardness of the matrix; they are filled with the pink rock, showing them to be of the age of that deposit.

The Brachiopoda in the pink rock were *Rhynchonella Bouchardi*, Dav.; *Rhynchonella Moorei*, Dav.; *Waldheimia* (*Zeilleria*) *Lycetti*, Dav.

Rhynchonella Bouchardi was the most abundant species, and exhibited all the varieties which occur in the same horizon near Ilminster. *Rhynchonella Moorei* was rare and small. *Waldheimia Lycetti* was of the typical form, and also resembled the Ilminster specimens. A few specimens of a variety of *Ammonites* (*Stephanoceras*) *communis*, and a large *Nautilus*, occurred sparingly in the conglomerate bed, generally of a yellowish colour.

In the brown stone over the conglomerate fine specimens of *Ammonites* (*Grammoceras*) *Thouarcense*, d'Orb., were obtained. In the hard white stone *Ammonites Germani*, d'Orb., were found in a very fine condition, and exactly resemble d'Orbigny's figures in the Paléontologie Française. This species is considered by some authors to be the same as *Ammonites hircinus* of Schlotheim. The presence of these Ammonites shows that the Jurense zone is here represented.

A curious *Rhynchonella*, character ill-defined, occurs in the brown rock, and appears to extend downwards into the conglomerate bed; some of the specimens seem to agree with *Rhynchonella jurensis*, Quenstedt, but they are generally more globose and larger shells; [illegible] may be called var. *Bothenhamptonensis.*

No specimens of marlstone Brachiopoda or Cephalopoda were found in the Conglomerate bed.

The results I arrive at are—(1) That the true Marlstone exists in the lower part of the stone band containing its characteristic Brachiopoda and *A. spinatus*; the upper part being full of *Rhynchonella serrata*, which is often overlain by a pink rock of the zone of *Rhynchonella Bouchardi*.

(2) That the conglomerate bed in the Bothenhampton section is not older than the age of *Ammonites bifrons*—the zones of *Ammonites falciferum* and *Ammonites communis* having been denuded and their worn fossils deposited in this bed. That in other localities the zone of *Am. bifrons* has been denuded.

(3) That no fossils derived from the marlstone were found in the conglomerate; and as so many fine specimens of *Rhynchonella serrata* were found, it is probable that the marlstone did not suffer denudation in this locality. We know from sections round Ilminster that *Rhynchonella serrata* is only found in the upper part of the marlstone.

(4) That the section at Bothenhampton showed that the zone of *A. jurensis* formed the upper part of the rock band.

In conclusion, I regret that want of material prevented my paper being more complete; but I must thank my Bridport friends for their kindness in affording me facilities for examining these beds, and hope that they will carefully record any excavations which may be made in this interesting deposit.

III.—FURTHER REMARKS ON THE CONISTON LIMESTONE.

By J. E. MARR, M.A., F.R.S., Sec.G.S.

I QUITE agree with Mr. Goodchild's statement in the July Number of the GEOL. MAG. that the stratigraphy of some of the areas in which the Coniston Limestone Series is developed "presents very considerable difficulties," so much so that in the areas of Cross Fell and Settle portions of the "country might be described as consisting of a gigantic fault-breccia," and that it is necessary "to go over a large part of this faulted area again and again" in order to interpret its structure. I do not know whether Mr. Goodchild would class me amongst the "less fortunate" ones who have not been over the ground again and again; possibly I have not devoted the amount of time which he has been able to give to the study of the rocks of the Cross Fell Inlier, but it must be remembered that Prof. Nicholson, with whom I had the pleasure of working at this inlier, has returned to the ground again and again during a long course of years, whilst more recently, he and I have devoted several vacations to its study, and we have carefully compared the beds and their fossils with those of adjoining and more distant areas. Under these circumstances we are, perhaps, justified in speaking with some confidence as to the order of succession of the series; for our knowledge of adjoining regions would certainly lead us to place more reliance on the fossils of the beds than on the apparent succession of the beds themselves, where the country partially resembles "a gigantic fault-breccia." Doubtless we have made mistakes, and shall willingly acknowledge them, when proved by ourselves or others, but proof is certainly required, and for my own part I must demur to Mr. Goodchild's "corrections" when they are only matters of personal opinion. When he publishes his evidence, if it is convincing, I will accept the "corrections," but until then I prefer our own conclusions, arrived at after considerable study of included fossils, as well as of the rocks themselves.

Mr. Goodchild chiefly comments upon our interpretation of the rocks of the Cross Fell Inlier, and adds some remarks upon my notes of the Craven area. It will be convenient to consider his comments upon each of these areas in turn.

The Bala rocks of the Cross Fell Inlier.—Mr. Goodchild states that for "field purposes" it is sufficient to divide these rocks into a lower shaley and an upper mainly calcareous series, and that "any local change from argillaceous to calcareous is, as might be expected, accompanied by a corresponding change in the fossils." If this be so, the fossil lists in our paper on "The Cross Fell Inlier" must be entirely incorrect, and our work practically worthless. Our principal aim was to show that the Coniston Limestone Series was divisible into three main groups, which I have referred to in my paper in the March Number of the GEOLOGICAL MAGAZINE as the Roman Fell, the Sleddale, and the Ashgill groups. Each of these groups contains both calcareous and argillaceous members, yet the fauna of each group differs markedly from that of the other two, whilst the calcareous and argillaceous members of each have usually many fossils in common; this will be seen by examination of our fossil lists, and I appeal to them as evidence. Not only are the fossils of the various groups different (whatever may be the lithological characters of the component beds of each), but we have shown that the faunas follow one another in an order corresponding with that observable in the equivalent beds at home and abroad. Previous experience warrants one in accepting such order in a complex district, rather than a division sufficient for "field purposes," in support of which no palæontological evidence is advanced. I may notice that in Swindale, which shows the most complete section of the Bala rocks in the Cross Fell Inlier, the actual order of succession is that which we have inferred from the fossil contents of the strata.

Mr. Goodchild believes that the Keisley limestone belongs to a higher part of his mainly "calcareous series than has been left by pre-Silurian denudation elsewhere in the area under notice." From this remark and the insertion in his table on p. 298 of an unconformity between the Silurian rocks and the Coniston Limestone Series, it would appear that he considers that there was denudation of the Coniston Limestone beds before the deposition of the Stockdale Shales. Will he give his evidence for this? He states that the Keisley Limestone is "faulted in all round," so that there can hardly be evidence at Keisley itself. The only localities we have seen in the Cross Fell area where the Skelgill Beds are shown, viz. Rundale Beck, the slopes of Dufton Pike, and the Alston Moor road, near Melmerby, do not exhibit their relationships to the underlying series, and in the adjoining Lake District there is perfect conformity between the highest member of the Coniston Limestone series (the Ashgill Shales) and the Skelgill Beds, yet the fauna of the Ashgill Shales is not that of the Keisley Limestone, and an analysis of the forms of the latter indicates that it is distinctly on a lower horizon than the Ashgill Shales (which are found in the Cross Fell area in Swindale).

On p. 296 Mr. Goodchild states that he believes the volcanic rocks of Dufton Pike, etc., are "of pyroclastic origin everywhere in this area," but he gives no evidence for this belief, which is directly opposed to Mr. Harker's opinion of the nature of these rocks (see his Appendix to our paper on the Cross Fell Inlier), based on careful microscopic examination.

Mr. Goodchild next notices at some length the geology of the slopes of Roman Fell, but he only gives the "facts as they appear" to him. Professor Nicholson and myself have re-examined the Roman Fell rocks since the reception of Mr. Goodchild's letter containing "the friendly hint." We are willing to admit that our map of the Roman Fell country is too generalized (though it was distinctly stated that it was a sketch-map for temporary use prior to the publication of the Geological Survey Maps), but we do not see that our general conclusions are thereby affected.

There is probably a cross fault between the Dufton Shales of Hilton Beck (Mr. Goodchild's Helton Beck) and the rocks further south, causing the latter to be shifted back to the east, so that the *corona* beds should not be taken below the Hilton Shales in the course of the stream. But we cannot recognize any evidence of the intercalation of volcanic beds between two bands containing *Trematis corona*, for the volcanic rocks on the east side of the Seat seem to us to be distinctly connected with the Skiddaw Slates, and to occur on the east side of the Knock-Flagdaw fault. We did not go over this part of the ground before our paper was written, as our object was not a minute description of the sedimentary and volcanic rocks of the Skiddaw Slate Series. Whilst, therefore, I see no objection to the intercalation of volcanic rocks in the *Corona* beds (it is well known that they are intercalated on more than one horizon between different sedimentary bands of the Sleddale group), I am not convinced that such occurs on Roman Fell, though we have recently re-examined the ground for this special purpose.[1] When Mr. Goodchild remarks, however, "I more than suspect that these Helton Moor volcanic rocks are the equivalents in time of those I named the Rake Brow Series," which he has elsewhere identified with the volcanic rocks of Eycott Hill, we look

[1] Mr. Goodchild appears to have misunderstood Prof. Lapworth's information about the *Corona* beds, for Prof. Lapworth tells me he knows of no *corona* beds at Girvan, or elsewhere in Scotland. Perhaps Mr. Goodchild refers to the occurrence of two bands of *Trematis* in the Shropshire area, which Prof. Lapworth tells me he has found there. In quoting so eminent an authority as Prof. Lapworth in support of a controversial point, surely we are justified in expecting that a correct version of Prof. Lapworth's statement should be given.

forward eagerly to the publication of the evidence on which he relies, as the position of the Eycott group is one of the most important problems in Cumbrian Geology, and there are serious difficulties in the supposition that the equivalents of the Eycott Hill rocks are anywhere intercalated between beds containing the *Corona* fauna.

I may here correct one statement made in our paper on the Cross Fell Inlier. The volcanic rocks south of Lycum Sike (which are very rotten) are not the Dufton rhyolitic rocks. As they are faulted against the beds further north, their position does not, however, affect the main question as to whether volcanic rocks occur intercalated between two sets of strata containing *Trematis corona*.

The term Corona beds is objected to, because of the stated intercalation of volcanic rocks between two Corona beds, and because "*Trematis corona* occurs in the Coniston shales in several localities." I cannot see that the term is inappropriate, even if an intercalation of volcanic rocks splits them up (which we do not admit). As to the occurrence of *Corona* in the Coniston shales, we maintain that it is limited to that portion of the Coniston shales which we have termed "*Corona* beds," and shall continue to do so until definite evidence to the contrary is adduced, for the fauna of the *Corona* beds is quite different from that of higher members of the Coniston Limestone series.

Mr. Goodchild fails to see any reason why the *Corona* beds "may not be contemporaneous" with the Drygill beds of the Caldbeck Fells. A very good reason is that they only contain one fossil in common, viz. the Brachiopod *Orthis testudinaria*, which ranges through Llandeilo and Bala rocks, and that the other fossils indicate a different horizon from that occupied by the *Corona* beds.

The Craven area.—Little need be said concerning the rocks of this area. My expression of opinion as to the age of the Ingleton green slates is of little value until the evidence is published, and I should not have ventured any opinion had that of previous writers been unanimous. I have, however, at various times, both alone and in company with Prof. Nicholson, examined the rocks of the Ingleton area with a view of finding the asserted passage from the Ingleton green slates into the Coniston Limestone series, and have seen no proofs of such passage.

The Ingleton green slates, or rather the coarser bands in them, are marked by an abundance of detrital mica, a mineral which is conspicuous by its absence amongst the volcanic rocks of the Lake District. Also, whatever the Ingleton slates are, they have undergone very considerable alteration by pressure metamorphism since their deposition, a metamorphism which seems at first sight far greater than that which affects the rocks of the Coniston Limestone series. I am content to await the judgment of petrologists on this point.

The concluding paragraph of Mr. Goodchild's paper contains a truism. But whether the persistent types of the Ordovician rocks are found in Craven and within the Cross Fell Inlier is another matter. I have not dwelt on the subject because I do not consider that the time has yet come for doing so. The work which I have done in the Lake District, both alone and with Prof. Nicholson and Mr. Harker, is merely preliminary to the elucidation of the general history of the district. Much remains to be done, both by careful microscopic study of the rocks and by examination of all the available fossil evidence, before the full history of the rocks of the Lake District and adjoining areas can be written. Mr. Goodchild has given us his interpretation, though without full discussion of the palæontological evidence.[1] Whether that interpretation is correct time alone will show, but in the meantime I shall bow down to no conclusions which are not fully supported by the evidence of the fossils, for the past history of geology shows us the errors which have arisen from misinterpretation of such evidence.

IV.—NOTE ON A GRANITE JUNCTION IN THE ROSS OF MULL.

By J. G. GOODCHILD, F.G.S.;

of Her Majesty's Geological Survey.

[Communicated by permission of the Director General of the Survey].

IN a review of Nicholson's "Geology of Cumberland and Westmoreland," which appeared in the GEOLOGICAL MAGAZINE about a quarter of a century ago, the reviewer observes, in referring to some remarks upon the Shap Granite, that this and other granites have clearly taken the place of the rocks whose position they occupy, and that, in fact, intrusive rocks can be shown, in a great majority of instances, to have replaced, rather than to have displaced, the rock masses which they invade. The reviewer's identity with a well-known Professor of Geology at one of the English Universities is sufficiently evidenced by his intimate acquaintance with the geology of British Silurian and Cambrian rocks.[2] Like much else that has emanated from the same source these particular observations were made a long time before geologists in general were disposed to give any serious attention to them.

---

[1] In support of this statement, I may quote a remark made by Mr. Goodchild in a paper read before the Geologists' Association on July 5th, 1889, in which he refers to the paper by Professor Nicholson and myself on the Stockdale Shales. "If we listen to our palæontologists we must classify the Graptolitic Mudstones with the Ordovicians; while, if we are guided by the physical evidence alone, then the Graptolitic Mudstones with their Ordovician fauna must go in the same group with the beds above, and be classed as Silurian." If Mr. Goodchild had studied our paper, he would have discovered that the Graptolitic Mudstones (there called the Skelgill Beds) do not contain a single Ordovician form, with the possible exception of *Climacograptus normalis*. Again, in the same paper Mr. Goodchild states that during the accumulation of the Browgill Beds "deep oceanic conditions prevailed, and the old colony of graptolites either migrated still further, or else it became completely extirpated here." A glance at our paper would have shown that two well-marked graptolitic zones occur in the Browgill Beds of the Cross Fell area, and that the graptolites of these zones are intermediate between those of the Skelgill Beds and those of the Lower Coniston Flags, which according to Mr. Goodchild "migrated from a different zoological province!" Mr. Goodchild's depressions, elevations, and migrations belong to a past generation who made much of "Colonies" and similar ingenious explanations; but it is refreshing to meet with them again, after the accurate work on Graptolites of Lapworth, Linnarsson, Tullberg, and others.

[2] A reference to the same phenomena is given in the Geological Survey Memoir on the Sedbergh District, in connection with some minette dykes there.

Some years after the review appeared Mr. C. T. Clough, of the Geological Survey, after a long and careful series of observations in the field, came to the conclusion that the Whin Sill of Teesdale—a well-known intrusive sheet of dolerite invading the Carboniferous rocks of the North of England—replaced these rocks, and had not wedged them asunder, as it had commonly been supposed they had done. Mr. Clough's observation made it certain that the total thickness comprised between any two given upper and lower horizons in the strata, invaded by this dolerite remained, exactly the same where the Whin Sill was present as it did where it was absent, and that the strata above it and below remained, not only at their normal distance apart, but were absolutely undisturbed by the intrusive mass, whatever its thickness might happen to be. Mr. Clough argued that eruptive rocks such as these had assimilated the strata whose position they occupy at present; and he further accounted for the uniformity of composition of the dolerite where the rock invaded happened to present a wide range of chemical composition by the theory that a kind of circulation went on throughout the molten mass, whereby the rock material, as fast as it was melted up, became diffused throughout the whole mass, instead of remaining more or less localised.

Facts of the same nature as those observed by Mr. Clough had been repeatedly noted in the areas adjoining by his colleagues on the Survey; and, indeed, every competent geologist who had examined the field-evidence was entirely in accord with Mr. Clough in his conclusions.

But the cabinet geologist declined even to consider the matter—he said that it was simply impossible that an intrusive mass could replace the rocks it invaded; and he found so numerous a body to agree with him, and therefore disposed to rest content with the old view, that it was clear to those who held more advanced views that there was no chance of the subject meeting with fair discussion for a long time to come. So the matter was allowed to drop, and the steady-going section of geologists again went on their way in peace.

It is somewhat remarkable that there should be so much reluctance to accept this view, considering that the best text-books had, long before, given illustrations of this very mode of occurrence of intrusive rocks, and that the maps and sections published by the Geological Survey furnished abundant evidence pointing to the same conclusions. And it is almost inconceivable how anyone who had worked out the inter-relations of these rocks in the field, could possibly adopt any other view. Apart from any theoretical bias that a field-geologist might have in this matter, he could not very well overlook the fact that his fellow-worker, the miner, has long been aware that trap rocks very often "cut out" the coal seams or other strata with which they come into contact. This is abundantly proved in the Midland coal fields, as well as in those of the more northern parts of the kingdom, and it is a rule of very general application elsewhere.

Some important problems relating to both physics and chemistry are involved in this matter. These I could not even attempt to solve. But some little additional field evidence gained while studying the behaviour of several granite masses in Cornwall, Cumberland, and Westmoreland, in some parts of southern Scotland, and especially in the Ross of Mull, seems to me to indicate the direction in which further research, systematically carried out, may lead eventually to a correct understanding of the facts.

Around the border of the Ross of Mull, chiefly on its eastern and south-eastern margin, the granite contains unusually large quantities of included masses of rock, chiefly quartzites, greywackes, and mica schists, identical in character with that of the Highland Metamorphic Series, which the granite here penetrates. In some of the larger granite quarries, as for example, those at Camas Tuadh on the west side of Loch Làthaich, and others again near Ardalanish, these included blocks occur in such profusion as to impart to the rock the appearance of a gigantic breccia, in which the granite itself plays but the rôle of matrix. In many instances the blocks are as much as twenty or thirty feet in length, and are but little rounded, nor are they much altered beyond the stage of metamorphism observable in these rocks at points far removed from the granite. The parent masses do not appear to have undergone much shearing prior to their engulphment in the granite, so that the lines of stratification, the false bedding, and the joints of the original quartzite are distinctly traceable through the included blocks in their present position. The inclusions appear to have been detached from the parent block by means of joint planes, and, once so detached, to have quietly floated away into the molten rock, without any further change specially noteworthy.

I had occasion, a year or two ago, to follow the boundary of the granite for some miles, beginning at its clear junction with the quartzites at Ard an Daraich, and following it from that place southward. The task of laying down this boundary upon the map was by no means as simple as it is in the majority of cases. Many granites come against their enclosing rock with a perfectly well-defined junction, often narrow enough to be covered with a knife edge. But the Ross of Mull granite behaves differently. In some respects, indeed, it may be said to shade off into the metamorphic schists around. It is not intended by this that the mica schists or the quartzites showed an increasing percentage of crystalline felspar in proportion to their nearness to the granite. The microscopic structure, as well as the field evidence, showed that this case forms no exception to the now-generally recognized rule in this matter. The rocks are granulitized, as might have been expected, but no transition can be observed from the one mineral type into the other. The gradation referred to is effected by the steady increase in the proportion of the masses included within the granite, as this rock is traced outward towards its peripheral zone. Beyond that zone, where some few masses of schist and quartzite still remain more or less attached to their parent rocks, the number of granite veins ramifying into the surrounding rock, along joints and other divisional planes, is so large that in places it is difficult to say whether the section before one should be regarded as a mass of schists traversed by granite veins or as a mass of granite with an unusually large percentage of included blocks. Some of the best sections for the study of these phenomena are along the coast near Carraig Mhòr and at Torr na Sealga. But even from the tourist steamer, on its way past the south coast of the Ross of Mull, in travelling from Iona to Oban, the phenomena are distinctly visible without the aid of a field-glass, so large are some of the masses of schist and quartzite included within the granite.

A close examination of the junction between the granite veins and the invaded schists gives some clue to the way in which this extraordinary *melange* of granite and metamorphic rock has been produced. The granite veins have evidently eaten their way into the surrounding rock, along joints or other planes of weakness, melting the adjoining rock as they advanced, and without wedging any of it apart, as the enormous pressure under which the granite was intruded might have been expected to do. Scores of examples, examined here and elsewhere, showed that the thickening of the wedges of molten rock, as they advanced into the strata beyond, was accomplished by the gradual removal of the rock along the sides of the wedge, the place of the rock so removed being taken by an equivalent bulk of granite, different in no respect but that of the size of its constituents from the granite nearer the central part of the chief mass. In many cases the course of the granite tongue can be followed along one joint, narrowing as it extends inward, and then turning off in a different direction along another joint, nearly, or quite, up to an intrusion coming from another part. The detachment of the blocks by means of wedges, which have eaten their way in along the joint planes, can be traced through every stage of quarrying up to complete isolation.

Once surrounded in this way by an envelope of molten rock, the extraction of the block, by the further enlargement of the wedges, was no difficult matter. The mass of schist so liberated floating upward into the main stream if the current was setting strongly in that direction; downward, if so determined by the relative specific gravity of the molten as compared with the unmelted rock; or remaining suspended if the relative specific gravity, etc. so permitted.

Probably the whole of the blocks so detached were destined sooner or later to undergo complete solution, and, in that form, to undergo amalgamation with the rest of the molten rock forced up from the reservoirs below. The process of diffusion in such a case may be likened to what takes place when a fragment of a more-fusible metal is introduced into a molten mass of a less-fusible metal. In the case where the two readily form an alloy the diffusion is effected completely, without stirring, or any other mechanical aid. This principle of diffusion seems to afford the clue to the uniformity of composition of the great majority of intrusive rocks, even where they *invade* rocks of very diverse composition. It may be remarked, however, that the uniformity referred to is by no means as general as it appears to be assumed is the case.

The sections in the Ross of Mull suggest that as the peripheral zones of a granite mass, gradually melted up, they may have furnished no inconsiderable proportion of the molten rock that worked up to the surface in the form of lava; although it is doubtless true that every part of the conduit contributed more or less. The peripheral contributions, being at a somewhat lower temperature, and therefore having a somewhat higher specific gravity than the molten rock nearer the middle of the ascending current, may have been carried downward for a time; but they were destined, sooner or later, to float upward with the rest.

Granite veins may thus be regarded as playing the part of capillaries in the circulatory system of the larger mass; or their function may be likened to that performed by the individual leaves of a tree, which elaborate products not used entirely by the leaves themselves, but which are destined for distribution by means of the circulatory system as nourishment for the plant as a whole.

The mode of attack of an intrusive mass is probably influenced very largely by complex inter-relations between the composition and the temperature of the invader and the rock invaded. To some extent also the results may vary in accordance with the degree of resistance to intrusion presented by the invaded mass. Where this resistance was comparatively low, as would happen in the case of intrusions taking place under small superincumbent pressure, a true laccolite would doubtless be formed. That is to say, the overlying rock might really and actually be lifted up with little or no replacement of the strata affected. But where the resistance to the enormous intrusive force was too great to be overcome by such rupture and displacement, the temperature of the peripheral zone was raised to the melting point proper to the degree of pressure exerted, and the invaded rock gave way by fusion instead of yielding by upheaval or by fracture.

In this way both of the recognized types of intrusion may find a simple explanation. Where a laccolite really does occur, that exceptional phenomenon would seem to indicate intrusion under comparatively-low superincumbent pressure and usually under such conditions as must obtain in the upper part of a volcanic cone.[1] But in the case of the majority of intrusive masses the molten rock has been forced in against greater resistance; the temperature of the invaded rock has thereby been raised to its local fusing point; the melted portions have been alloyed by circulation with the general magma; and in this way the intrusive mass would, step by step, replace the rock invaded, and would replace that rock by igneous rock of uniform composition without displacing the rock beyond in the least.

---

[1] It should be noted that as this upper part is that which is most readily denuded away during subsidence beneath the waves, true laccolites can be but rarely preserved in a fossil state.

V.—The Malvern Crystallines.[1]

By the Rev. A. Irving, D.Sc., B.A., F.G.S.

THE author having made an examination in the field of the Malvern Crystallines, during a residence of ten weeks at Malvern in the early part of the year, and having had the advantage of Dr. Callaway's company over portions of the ground towards the end of the time, offers here an outline of his observations and the general conclusions to which his field-work has led him, reserving, for the present, all details of microscopic work.

I. He agrees with Dr. Callaway[2] (with one doubtful exception) that the whole crystalline mass, from end to end, is of igneous origin, but cannot follow that observer in regarding the granites as injected into the diorites (the "syenites" of Phillips and Holl). The author's observations rather lead him to doubt if any true sequence can be made out between these two rocks (using the terms in a broad generic sense), the observed phenomena seeming to square better with the view, which would regard them as segregation-products of "one original unerupted magma," as was suggested more than forty years ago by the late Professor J. Phillips, F.R.S.[3] (see Mem. Geol. Survey, vol. ii.); and he regards the coarse pegmatitic varieties of granite (the "binary granite" of Callaway) as the *siliceous residuum of the magma, after the whole (or nearly the whole) of the silicates of the heavier bases had crystallized out*;[4] applying this even to such a coarsely-crystalline mass as may be seen on the top of Worcester Beacon, where one mass of individualized quartz was observed nearly a foot thick.[5] He bases this view on such facts as the following:—

1stly. Upon the way in which the dioritic and the granitic rocks of the chain graduate into one another (as in Worcester Beacon and North Hill), or alternate with one another (as in the Swinyard Hill);

---

[1] A paper read before Section C. of the British Assoc., Edinburgh meeting, 1892.

[2] See the two able papers by that author in the Q.J.G.S. for 1887 and 1889.

[3] Even at that early date Phillips had as clear an idea of the differentiation of a homogeneous fused mass into a heterogeneous crystalline mass as a recent writer in "Natural Science" (June, 1892), whose application of the theory of "osmotic pressure" (as applied to "dilute solutions"), to help him to construct a "sequence of plutonic rocks" (a theory which can hardly be said as yet to have established itself in Chemical Physics) seems rather strained. Durocher's principle of "liquation" is probably nearer the truth. But as different physical conditions (chiefly temperature and pressure) determine the allotropes of one and the same chemical body, so they undoubtedly are large determining factors of the order of crystallization of minerals out of a given magma, and the consequent composition and critical temperature of the residual magma at any stage of rock geneisis. It is hardly necessary to state, that with much that is contained in the article referred to the present writer entirely agrees.

[4] The fact that most of the felspar in the Malverns turns out to be plagioclase (carrying over many of the "syenites" of the earlier writers to the diorites) is in favour of this view; since "soda, weight for weight, fluxes more than potash;" and "lime may produce, with a great number of infusible, or slightly fusible, silicates, compounds which melt easily." (Percy, "Fuel, etc." London, John Murray, 1875, pp. 73, 75).

[5] Individual hornblendes, comparable for size with these, were not met with in *the field*, but some may be seen in the Museum at Malvern College.

it being a rare thing to find either the granite or the diorite displaying anything like a dyke-relation to the other, the few cases in which there is a semblance of such a relation being perhaps best explained by ***internal stresses*** setting up slight local shearing-movements (under the influence of gravitation and perhaps other forces) along planes or zones of weakness in the rock-mass caused by ***unequal contraction of the more acid and the more basic portions during congelation.*** (The gradation from diorite through a biotite- or hornblendic- granite to a very coarse pegmatite may be seen at West Malvern near the church.)

2ndly. Upon the way in which the felspathic and the quartzo-felspathic veins ramify in all directions through the diorite, as pointed out long ago by Phillips (*loc. cit.*). (North Hill, and the quarries at North Malvern and at the Lower Wych, afford excellent examples of this relation.)

3rdly. Upon the fact that very often the hornblendic rock is observed to be more completely basic in immediate contiguity with the felspathic veins; whereas we should expect the contrary to be the case, if the latter were injected veins.

4thly. Upon the very significant fact, that the quartzo-felspathic veins, even when less than an inch in thickness, have a coarsely-granular texture, this being so manifest macroscopically (especially when the rock is slightly weathered) as to make it impossible to believe that they crystallized in contact with a colder rock after injection into it.

On the other hand, we may perhaps understand the facts observed, with the light thrown upon them from the *rate of solidification of basic and acid slags* observed years ago by Macfarlane.[1] The observed field-relations of the Granite-diorite series at Malvern seem to accord with his observations on slags, which warrant the hypothesis that the more *basic* portions of the magma solidified more rapidly and at a higher temperature than the more acid veins, the latter continuing for a long time in a viscous condition,[2] in which condition they would of course act as "lubricating material" between the already solidified basic portions, allowing easy relative movement of those parts, as the result of internal stresses, set up within the mass. It is possible that in this way many cases of schistosity observable in some of the felspathic veins may have been produced at that stage of their history. The author feels the more justified in putting forward this view, from the differentiation of structure and composition of parts of the same igneous intrusive mass observed years ago by Allport in some dolerites; from the more remarkable differentiation of parts of the same dyke in continuous cross-sections described by Dr. Andrew C. Lawson, of the Canadian Survey, in a paper which the author received last year from that distinguished geologist (American Geologist, March, 1891, on the "Petrographical Differentiation of certain Dykes in the Rainy Lake Region"); from known cases of the derivation of basic and acid rocks from the same magma in well explored volcanic *foci*;[1] and from the fact that he has himself found the Bronsill intrusive dolerite (near Eastnor) pass into an almost pure pegmatite in one part. Even where such a rock occurs as kersantite or mica-diorite, there is not always evidence to point to contact-alteration as the origin of the mica. It seems easier to regard this rather as a *primary* mineral constituent of the rock in places[2] (mica taking the place of the hornblende of the prevalent diorite); for in one place (West Malvern) the kersantite seemed to vein the adjacent rock, while in the greatest exposure of kersantite seen in the Malvern Range it was intersected by basic dykes, unmistakably intrusive, and no other acid rock was exposed. This was in the quarry at the north-west corner of Swinyard Hill, where no progressive alteration could be observed macroscopically in the kersantite as it approached the basic dykes.

---

[1] See "Canadian Naturalist" for 1864, quoted by the present writer in "Met. of Rocks," page 70 (footnote), "On the Origin of Eruptive and Primary Rocks," by T. Macfarlane, now chief Analyst to the Dominion Government. It is instructive to note the revival of the ideas of Macfarlane and Naumann in the "New Geology," as the fogs of "regional dynamic metamorphism" clear away.

[2] What the late Dr. Percy called "pasty fusion." See "Fuel, etc.," page 63. Macfarlane's observations of the wide range of temperatures, which holds good for this condition of "pasty fusion" in *acid* slags, extending both above and below the temperatures at which the more limpid *basic* slags rapidly congeal, explains how in some cases thin felspathic veins appear to fill fissures in the already solidified, but still hot, amphibolitic rock-masses. In this sense some of them may, perhaps, be regarded as "injection-veins." But they are a minor feature in the Malverns.

II. The only *intrusive rocks* the author has been able to recognize from end to end of the chain are (a) *felsites*, becoming at times quartz-porphyry; and (b) *dolerites* of different varieties, including diabases.

The *felsitic dykes* contain occasionally inclusions of a basic rock (probably diorite altered by contact), and are very well seen at North Malvern, at Gold Hill north of the Wych (porphyritic), about Wind's Point, in the Raggedstone Hill (as described by Dr. Callaway), and in other localities.

The *dolerites* are much more common, and enter much more largely into the geotectonic structure of the range, being met with from end to end of it. They are often aphanitic in texture, and in a great proportion of instances have undergone in part intense crushing in the subsequent mountain-building stage of the history of the region, with re-cementation into a solid breccia. Many of the boldest crags consist of these rocks (North Hill and in Rushy Valley above Great Malvern). In all such cases a special point was made by the author (in the light of experience gained in former years in the Eifel, in the Bozen country, in the Neapolitan region, in Charnwood Forest and in Snowdonia) of searching for evidence of *tuffs*, but without finding any, although one or two doubtful cases are mentioned by Mr. Rutley.[1] He considers, therefore, that evidence is wanting of any *volcanic rocks*[2] (*stricto sensu*) in the Malvern Chain, except those of a later date recognized as Pebidian on the flank of the Hereford Beacon. In some parts of the range a rough parallelism can be observed between the dykes, and the prevalent trend seems to be N.W. and S.E.; but there are many exceptions to the rule, and they have had very little to do with determining the present contours of the hill-flanks.[3] In some cases they have acquired a slabby structure, as if from roughly parallel divisional planes produced by shrinkage during the final stage of their solidification. Their intrusive relation to the *Granite-diorite* series seems to be established by (i.) their dyke-like form with boundary-walls often extremely well-defined;[4] (ii.) the inclusion in them of masses of the older series (such inclusions consisting of granite, or of diorite, or of diorite veined with felspathic material); and in one instance (in an old quarry at North Malvern at the extreme end of the range) a large inclusion of hornblendic rock is seen to be itself previously intersected by felsitic veins, which are truncated off abruptly at the boundary of the enclosed mass,[5] pointing to an earlier date for the intrusion of the felsite. The enveloping dolerite itself has here acquired a slabby curvature, as if from the resistance of the included mass producing internal stresses in the dolerite during its solidification. North Hill, Worcester Beacon (near the summit and in the higher parts of Rushy Valley on its lower eastern flank), the quarry at the N.W. corner of Swinyard Hill, the Gullet Quarry, the Wych Road, and St. Anne's Well, are some localities, where this dyke-relation seems clear. These intrusive masses appear to be portions of a deeper magma, which (first the acid, then the more basic portions) simply *flowed into great fissures of the Granite-diorite series*, as the latter was dislocated subsequently to its consolidation. Everything seen goes to show that these intrusive masses were *altogether passive as regards the earth-movements*, which have brought the Malvern crystallines into their present position. The author's observations on this point thus agree with conclusions put forward during the last two decades by Doctors Suess and Heim.[1] The researches of Dr. Callaway and Mr. Rutley make it probable that some of these basic intrusive dykes, which look so much like dolerites under the hammer and the lens, are really fine-textured diorites or epidiorites; but this does not materially affect the view put forward here as to the part they play in the geotectonic structure of the Malvern Chain.[2]

---

[1] See in particular the very instructive instances described by Credner (*Elemente der Geologie*, sixth edition, page 587) at Predazzo and Monzoni, in the Italian Tyrol.

[2] To contend that the mica of kersantite is always a *secondary* mineral would land us in the difficulty of having to recognise it as such (by "endogenous" alteration) in cases where kersantite occurs as an *intrusive* rock, as for examples in the Devonian and Carboniferous of the Hartz region, and in the Culm of Lower Silesia (Credner, *op. cit.* pp. 464, 500).

---

[1] "On the Rocks of the Malvern Hills," Q.J.G.S. August, 1887.

[2] The extended sense in which this term has been lately applied by Sir A. Geikie, in his two Presidential Addresses to the Geological Society, is much to be deprecated, from the confusion of thought it is likely to engender and the violence done to the literature of petrography. The term "volcanic" is used as equivalent to "igneous," and the term "eruptive" is made to do duty for "plutonic." In this way the Lewisian gneiss is included in his volcanic series (1891 Address, p. 32). Introduce the pressure of the Archæan atmosphere, and all the facts on p. 33 tell the other way. To speak of such rocks as tourmaline-granite as parts of a great "eruptive-stock," as Credner (*loc. cit.*) does of the more deep-seated but unerupted igneous masses at Predazzo and Monzoni, is one thing; but to take the great Archæan gneiss series by themselves and label them "eruptive" or "volcanic," when there is no evidence whatever of lava-flows or tuffs to connect their history with what is usually understood by *vulcanicity*, is another thing altogether.

[3] Dr. Holl seems to have generalized rather hastily on this point. See Q.J.G.S. vol. xxi. pp. 72, *et seq.* "On the Geological Structure of the Malvern Hills, etc."

[4] Excellent examples may be cited from the Worcester Beacon and its flanks. One bold crag high up the south flank of Rushy Valley is half granite, half dolerite, the latter much crushed and brecciated, with a trace of cleavage here and there. The junction is unmistakable both on the north-looking vertical face of the crag and on the ground-plan above.

[5] In this and some other cases the included mass seems not improbably to have fallen into the later and more basic magma, and to have floated off after the manner of some of the masses described by Dr. A. C. Lawson in the Rainy Lake Region.

III. *Structural Phenomena.*—These seem to fall for the most part into five categories:—

- (i.) *Diorite-gneiss* (rocks composed of the materials of diorite with a gneissic arrangement).
- (ii.) *Gneissose* (*flaserig*) *structures.*
- (iii.) *Phyllolithic rocks* approximating in various degrees to the character of a true schist.
- (iv.) *Shear-planes* (often highly slickensided).
- (v.) *Crush-planes and zones.*

A few remarks, as brief as may be, are called for on each of these.

(i.) *Diorite-gneiss.*—The most perfect examples of this were met with at North Malvern. The rock here is for the most part a massive diorite, but occasionally the parallel veining of the felspathic and hornblendic constituents is very marked, in parts of the rock which do not appear to have undergone any deformation by dynamic action. The veins are often a mere fraction of an inch in thickness, and the veining has no relation whatever to the shear-planes which intersect the rock. In other places the veined structure has undergone some deformation, giving the rock a more schistose structure, the veins being apparently stretched out, the felspathic particles somewhat rounded (as the quartzes are known to be in quartz-porphyry from abrasion in a viscous "flowing" magma), and arranged in linear series, reminding one of a loose string of beads. The rock has at the same time become distinctly fissile under the hammer in the direction of the foliation.[1] Kneading-out or stretching-out rather than crushing-out seems to have been the order of things in such cases. This description applies to the "shear-zones" of Dr. Callaway. Good examples are seen in the Gullet Quarry (south end of Swinyard Hill), in the quarry south of the Wych Pass (where larger masses of felspathic material are drawn out into slabs), in all the three quarries at West Malvern,[2] and at North Malvern above the reservoir, where they bear no relation whatever in their orientation to the crush-planes exposed in the quarries below. The differential movement in such cases, *so far as each plane of shear is concerned*, seems to have been but slight; no more, in fact, than could be referred to unequal contraction of adjacent portions of the rock-mass during the later stage of consolidation. In some cases, as in the quarry above the church at West Malvern, such a foliated zone occurs on both sides of a divisional plane, as if the shearing had been produced by sliding along a shrinkage-crack, while the mass on either side of it (in this case a very felspathic variety of diorite or a biotite-granite) was still in a pasty condition.

---

[1] Since this was penned "Suess-réchauffé" has been largely served up for the delectation and mental nutriment of Sections C and E, by the respective presidents of those sections. The present writer can hardly find fault with Professors J. Geikie and Lapworth for giving such powerful expression to ideas which have haunted him for years past, as the references in his "Met. of Rocks" to Suess and Heim plainly show. But they can hardly lay claim to *novelty*, seeing that the "Antlitz der Erde" was outlined in (the closing chapters of) Suess's "Entstehung der Alpen" (Vienna, 1875). Lapworth's conception of the "wave and trough" deformation of the rind, following Suess and Heim, implies a *yielding under-zone in the lithosphere*, which he will find hard, with Dissipation of Energy, to harmonize with the Huttonian uniformitarian doctrine, and will act as an "aqua regia" upon the gold of his "wedding-ring," and the blessed union symbolized by it. And the recognition of the *passivity of igneous inflows and outflows* and their location generally along the *concave* side of the asymmetrical mountain-wave disposes once and for all of the fiction of the "roots of the mountains," of a veteran writer on physical questions, even as it has made it impossible for the present writer to accept it. (See in particular Heim's *Mechanismus der Gebirgs-bildung*, Bd. ii., p. 178; Basel, 1878.)

[2] Those who will be at the trouble to consult the author's "Metamorphism of Rocks" (pp. 53–55) may see that on general grounds we may recognize the presence of traces of highly superheated H_2O as a potent factor in differentiating the amphibolitic rocks from the felsitic and pyroxenic magma which subsequently filled up the fissures in them. This is thoroughly borne out by Dr. Kroutschoff's synthesis of hornblende (see GEOL. MAG. 1891, p. 303).

Diorite-gneiss would seem to result from the segregation of minerals in the course of their development; and its conversion locally into "diorite-schist" (amphibolite) to *differential movement prior to final consolidation of the materials.* The idea suggested itself to the author when Dr. Callaway's paper was read at the Geological Society in 1889, and certainly seems to work very well in the field.

(ii.) *Gneissose (flaserig) structures.* This kind of alternation of more basic and more acid layers, giving the rock at times a very stratiform character, may be most easily explained as due to original veining, accompanied possibly in some instances by some differential movement prior to complete solidification. This simulation of bedding is most conspicuous about the central parts of the range, as at Wind's Point, in the Hereford Beacon, and in the quarries by the roadside at Little Malvern; but at the latter place the rock again puts on its more massive structure in the quarry half-way up the flank of the hill.[3] On the ridge of Swinyard's Hill also this slabby structure of alternating hornblendic and felspathic layers may be observed. Various degrees of deformation of these layers (especially those of a more basic character) may be seen; and in places—as in Rushy Valley above Great Malvern, and in the Raggedstone quarry—the basic minerals have been more completely pulverised and rendered incoherent by the grinding action to which they have been subjected between the harder and more rigid felspathic masses. This was observed to be especially the case where the stratiform structure of the rock had suffered considerable contortion against massive intrusive dykes of basic rock,[1] and is, therefore, one of the phases of deformation which may be with some certainty referred to dynamic action since the consolidation of the whole mass. Where this seems to have been excessive, some mica has made its appearance in the felspathic distorted bands of the rock, probably at the expense of the original felspar.

---

[1] It appears to have become a rock of the Amphibolite-type of continental writers (resp. "felspar-amphibolite" or "diorite-schist"). See Credner (*op. cit.* p. 111), also Kalkowsky, "Elemente der Lithologie" (Heidelberg, 1886), p. 209.

[2] At the north end of the village is a disused quarry, which does not seem to be noticed by recent writers. In a certain broad zone of the rock exposed there, the structure here under consideration is splendidly shown.

[3] Here, however, the diorite is intersected by felsite dykes. It is interesting to note this injection of felsite into the more banded and more massive portions of the same broad orographic zone of the Malvern chain, pointing to community of age in the two. It is curious also to see how this was overlooked by earlier writers, when they wrote so confidently about these gneissose portions of the crystalline *massif* as bedded sedimentaries. (See *e.g.* Symonds "Old Stones," pp. 18, 19.)

(iii.) *Phyllolithic rocks* approximating in various degrees to true schists. These seem to be very local in their development.

(a.) *Hornblende-schists.* In some of these the deformation of the hornblende crystals is the chief feature; and it seems probable that this mineral deformation, without any conspicuous shearing-movement, has occurred since the mass became fairly solid, and as a result of *static* rather than dynamic forces. It seems to occur in the more massive portions of the diorite, even where the rock-mass as a whole assumes a stratiform character, as in the large quarry at Wind's Point and in the quarries at Little Malvern. Something of this sort of crumpling was observed also in the more basic rocks extensively quarried at the Hollybush Pass.

In other cases distinct parallel planes of foliation, with marked differentiation of the minerals are seen, and lenticular plates of quartz are common, sometimes a quarter of an inch or more in thickness. This structure is well seen in the larger of the two old quarries at the south end of Raggedstone Hill, in the crags on the ridge south of the Wych, and in the crags near the ridge nearly half a mile north of the Wych above Rock Villa. Observations in the field make it difficult to resist the conclusion that these local developments of an apparently perfect schist are directly related to the greater resisting-power of the already consolidated felspathic masses contiguous to them, with which, in every case, so far as the writer's observations go, they are in close relation, either alternating with such masses (as in the crags mentioned), or the schistosity (as in the Raggedstone Quarry) being most definite and perfect in close contiguity with massive quartzo-felspathic veins, and gradually dying away into the undeformed hornblendic mass. The deficiency of felspar—if not the entire absence of that mineral—seems to be accounted for by its previous concentration in the adjoining felspathic veins; while the flattening out of the quartz has taken place in such a way as to make it probable that, when the deformation began, that mineral was in the colloid state, owing to the concentration in it of the traces of water present in the original magma, as the anhydrous minerals separated out.[1] This deformation probably occurred when the whole rock mass was still at a fairly high temperature; and, that the present structure resulted from pressure acting upon a mass, in which the minerals were already differentiated in the manner indicated prior to solidification, and *not causing that differentiation*, seems the more probable from the fact that traces of residual felspar are often seen in these quartz-veins. It is, at least, as easy to explain the observed facts in this way as to suppose that pressure has brought about a deformation of original felspar, and led to the removal of its bases with the separation-out of quartz. The same sort of flattening-out (in pancake fashion) of the quartz in masses of considerable size (several inches long) was observed in some cases of the more felspathic masses, where the mass, as a whole, has been squeezed into a dyke-like form. A notable example of this was seen in the Dingle Quarry at West Malvern.

---

[1] On the top of the crag referred to (*Ante* p. 454) on the south side of Rushy Valley the granite becomes flaggy close to the junction-planes, as if from shearing, while the dolerite on the other side of the junction-plane is crushed to a breccia. In nother crag lower down the gneissose granite is bent round against a massive olerite. Good examples of this gneissose structure may be seen by the footpath, alfway up the hill.

[The retention at high temperatures of the water of hydrated silica by sufficient pressure acting hydrostatically is only another example of the same principle as we have learned to recognize in the fusion of limestone, without dissociation of the CO_2 from the CaO, as a necessary stage of marmorization. If P represent the pressure required to prevent dehydration of colloid silica or dissociation of $Ca\,CO_3$ in any given case (at high temperature), it is easy to see that P may be the sum of—

the pressure due to its depth in the lithosphere (p_1),
the pressure due to the depth of the hydrosphere, if any (p_2), and
the pressure due to the supernatant atmosphere (p_3).

The equation $P = p_1 + p_2 + p_3$ is therefore true in all cases; but with recession in time p_2 and p_3 would merge into one another, p_2 diminishing, and p_3 increasing, as we approached the "pre-oceanic" conditions of early Archæan time in the history of the lithosphere, and even so much of p_1 being added to the compound hydro-atmospheric term, that the depth in the lithosphere necessary to furnish P would not be very great. That is to say, the requisite pressure might be found at or near the surface of the lithosphere.

---

[1] The author has discussed this fluxing-action of *traces* of H_2O (and perhaps other oxides) elsewhere. (See "Met. of Rocks," pp. 48–50; also p. 86, where the case of quartz in granite is considered.) It may be as well to remind geologists that "fluxing-action" may display itself in *retarding congelation* of mineral matter as the temperature of a liquid or viscous mass falls, just as much as in hastening the fusion of a solid mass. These are only two aspects of the same law. The proportions in which SiO_2 may hold H_2O in combination, extend over a very wide range; and it is almost certain that the critical temperature of hydrated silica is lowered in some proportionate relation to the amount of H_2O present. Compare the results of the Author's own experiments, given in App. i. note C of his original thesis put forward in January, 1888 (p. 100 of the published work). It is possible that slight hydration of SiO_2 at depths might exist even at a red heat, pressure preventing the escape of water (as in Dr. Kroutschoff's recent experiments). Dr. Callaway has come near the idea on p. 500 of vol. xlv. of Q.J.G.S., though he seems to mistake this fluxing action of water for "solution."

This is "uniformity" indeed, but quite a different thing from the "uniformitarianism" of the Hutton-Lyell school.]

(b.) *Sericite-schists.*—The writer has adopted this term from a letter written to him by Dr. Callaway for the satiny, distinctly-foliated, and contorted rock, which is exposed on the western side of the larger quarry at Raggedstone, and is unconformably overlain by the Hollybush Sandstone. He has seen nothing like it in any other part of the Malvern Hills. It is something more than a *phyllite,* and reminds one of nothing so much as the Casanna and other younger schists of the Alps. It appears to be a fragment of the lithosphere belonging to a much later Archæan stage of development than the rest of the Malvern Chain, a stage of development in which super-heated water or steam has played a prominent part, rather than to the pyrogenic stage of rock-genesis,[1] to which most of the rocks of the Malvern Chain may be referred. The writer failed in his attempt to trace a gradual transition from them into the gneissose rocks adjoining these schists.

Taking into account the great discordancy that exists between these schists and the overlying Upper Cambrian strata, it appears easier to look upon them as the sole remnant (now exposed to view) of the younger Archæans left by the extensive denudation to which the whole region must have been subjected in early Cambrian and later pre-Cambrian times, rather than as having been "manufactured" simply by those dynamic agencies, through the instrumentality of which the earlier mountain-building movements of the Malvern region were effected, though probably somewhat modified by them.

(c.) *Micaceous phyllolithic rocks.*—An alleged case of conversion of a felsite into a "mica-schist" in the Raggedstone has been described by Dr. Callaway. The writer has observed something of the sort in some of the quartzo-felspathic veins, which are so well-developed in the old quarries at Wind's Point and Little Malvern (near the Roman Catholic Chapel), that they have been instanced over and over again, by writers on the geology of the district, as clear cases of truly-bedded sedimentaries; though a closer examination of them, in the light of experience gained in other parts of the range, makes it far more probable that they are deformed crystallines, rather than worked-up clastic materials. Some of these more felspathic individual veins have acquired a structure (a cleavage-foliation) approaching and simulating true *schistosity,* becoming easily fissile under the hammer, with white mica plainly developed macroscopically on their planes of cleavage. This, no doubt, is a secondary product due to the action of infiltrating water, and formed at the expense of the felspar; but it is difficult to see why such a rock should be designated a *schist* (*stricto sensu*) any more than some laminated sandstones of Mesozoic age, on the lamination-planes of which a similar deposit of secondary mica has taken place. Call them what you will, they are certainly very different things from the older mica-schists of the Alps, in which we meet with well-developed *accessory* minerals, such as kyanite, staurolite, and garnet. It seems doubtful if anything more than "cleavage-foliation" is to be seen in these cases.

---

[1] Compare "Metamorphism of Rocks," p. 91, where the distinction here implied is clearly drawn.

(iv.) *Shear-planes.*—These are very conspicuous structural features of the rock-masses exposed to view in the extensive quarries at North Malvern, at West Malvern, and at the Hollybush Pass. They seem to be the "divisional planes" of Mr. Rutley. Occasionally, as in the largest quarry at North Malvern, a rough parallelism may be observed in their arrangement, but more extensive observation shows that this is only a local and accidental circumstance. Generally they cut through the rock-mass in all directions and at all angles to the quarry-face, and the evidence they afford of sliding movements justifies one in regarding them as entirely mechanical in their origin, and due to crushing on a grand scale, acting along planes of weakness in the rock, quite similar to the crush-faulting which has been described by Dr. Stapff in the St. Gothard granite cut through in the railway tunnel.[1] They frequently intersect at all angles what we may call the "master-joints" of the rock, which appear to owe their origin to the shrinkage of the mass as a whole during solidification; and they are not in any way petrographically related to the adjoining holocrystalline, and often massively-crystalline rock. It seems impossible, therefore, to regard them as traces of anything of the nature of bedding. The mineral changes wrought by dynamic action on these divisional planes in the mountain-building stage, appear to be entirely in the direction of degradation of the basic constituents of the adjoining rock into oxides of the heavier metals (chiefly haematite), after pulverization of the rock for the thickness of a few millimetres. They are often conspicuously slickensided. Possibly some of the iron oxide may be present as carbonate, synthesized by the action of carbonated waters from the surface in the presence of organic matter in solution in such waters reducing the peroxides to protoxides; but these results are altogether secondary, and have nothing to do with the genesis of the rocks. The same remark probably applies to epidote, which is rather abundant as an infilling material in the smaller cracks of the diorite (especially at North Malvern), and was derived in all probability by the agency of infiltrating water from the hornblende.

(v.) *Crush-planes and zones.*—Where the original rock was very hornblendic this has been degraded into what some would call a "chloritic-schist," and some of these have been at times described by eminent writers under this term. Yet they can hardly be correctly termed schists at all; for they are so incoherent that it is impossible to get a piece capable of being sliced. They might, perhaps, be described as rotten slate with a very irregular cleavage. The original hornblende appears to have been completely pulverized in the presence of interstitial water, and, by the help of this water (or by water introduced subsequently), to have been wrought into a fine pasty mass, upon which a crude cleavage-structure has been induced by pressure. Several narrow zones of such chloritic masses with a phyllolithic structure are cut through in the Wych Pass; and they appear to have been localised by slight faulting. But by far the best example seen is in the quarry just north of the old pumping-station at North Malvern, to which the proprietor directed the writer's attention, as a case of a "blue marl" among the crystalline rocks. An inspection soon revealed the fact that the highly basic rock had been crushed here against a massive multiple vein of quartz, the most powerful development of vein-quartz observed in the whole range. The quartz-vein was itself extensively fractured, and the chlorite, as a fine powder, had worked its way into the fissures; but the two minerals remained completely individualized and distinct, showing no apparent tendency to enter into new chemical relationships under even the intense pressure to which the mass here had been subjected. This observation was repeated several times, after being first made in the early part of one's investigation; and reflection upon the extreme extent to which a hornblendic mass had thus undergone deformation (where, owing to the great power of resistance of the quartz-vein, conditions were exceptionally favourable to local concentration of mechanical force), threw much light upon many facts subsequently observed in other parts of the range, and served as the clue to some of the explanations which have been ventured upon in the present paper.

---

[1] See GEOLOGICAL MAGAZINE, 1892, p. 6.

Repeated observations of the Malvern Crystallines tend to force upon the mind the idea that rocks rich in hornblende, or almost entirely composed of that mineral, yield far more to pressure *without crushing*, than do the more felspathic portions, or even the dolerites. Hence it seems to follow that, where the original rock was very felspathic, either from the presence of more numerous felspathic veins, or from the more abundant distribution of felspar (and in some cases much quartz) through the rock, we get a brecciated mass along a plane of thrust, instead of anything approaching to schistosity. Examples of such are seen in the quarries at North Malvern, and in the cutting on the Wych Road just outside the quarry by Rock Villa. Again, in the same quarry-face (as at Little Malvern and Wind's Point) the more massive diorites have apparently undergone but slight deformation, while the thinner masses, which alternate with the felspathic veins, have been degraded into a rock with a more or less phyllolithic structure, in which chloritic material is abundant as a degradation-product of the original hornblende.

GENERAL CONCLUSIONS.

1. The field-relations observed among the crystalline rocks of the Malvern Chain point to the conclusion that for the most part their petrological morphology originated in *diagenetic paramorphism* and not in any subsequent metamorphism.

2. As regards the structural features (including schistosity) these have resulted to a large extent from the action of mechanical forces; such results being chiefly of a *metataxic* nature (as the author has defined the meaning of the term elsewhere), exhibiting various phases of deformation of the original crystallines, while the action of

dynamic forces in altering the atomic relationships of the chemical constituents of the rocks, *quâ* the development of new minerals, would appear to have been very limited.

3. In the present state of our knowledge the two most interesting questions presented to us by these rocks would seem to consist (*a*) in determining to what extent such dynamic deformation, as we actually observe, has been prior or posterior to the ultimate solidification of the various parts of the original magma; and (*b*) in determining to what extent simple atomic interactions leading to molecular segregation, supplemented by the action of gravity upon minerals of various densities and by forces of a tidal nature acting upon the magma as a whole, may have caused the vein-structure and the stratiform arrangement, which, whether in its original or in its deformed condition, has constituted one of the most puzzling phenomena presented to the minds of investigators of the Malvern crystallines.

4. The phenomena presented by these rocks as a whole seem to lend no support to the doctrine of "regional metamorphism" as usually understood, since, when field-relations are duly considered, it becomes far easier to explain such simulations of "bedding" as are met with, by mechanical deformation of crystalline rocks, to which a diagenetic stratiform structure had been imparted, than by the hypothesis of reconstruction of crystalline minerals out of clastic materials.

5. The writer, having made free use of the published writings of Phillips, Holl, Rutley, and Callaway, and of the valuable results of microscopic work published by the two gentlemen last named, and having approached the subject in the light of the principles advocated by himself in 1888–9, and since, is happy to find himself to a great extent in accord with Dr. Callaway, though unable to follow him to the full extent in the matter of "dynamic metamorphism."

NOTICES OF MEMOIRS.

ABSTRACTS OF PAPERS READ BEFORE THE BRITISH ASSOCIATION, EDINBURGH, AUGUST, 1892.

I.—ON THE "GRAMPIAN SERIES" (PRE-CAMBRIAN ROCKS) OF THE CENTRAL HIGHLANDS. By HENRY HICKS, M.D., F.R.S., Sec. Geol. Soc.

IN his address to the Geologists' Association in the year 1883 (Proceedings of the Geologists' Association, vol. viii. p. 270), the author gave the name of "Grampian Series" to a group of rocks which occupy an extensive area in the Central Highlands. He described them briefly as "tender gneisses, bright siliceous schists, chiastolite schists, quartzites and limestones," also some "chloritic schists." He considered them as of pre-Cambrian age, and all the evidence since obtained tends to confirm this view. It is quite possible, of course, that newer rocks may be in places entangled amongst them, and the author pointed out certain lines running from

N.E. to S.W. where there are indications of newer rocks in broken folds, but the majority of those which he claimed as being of pre-Cambrian age are now generally admitted to be older than any of the Palæozoic rocks of that area. The further descriptions of these rocks now given have been prepared with the kind assistance of Professor T. G. Bonney, D.Sc., F.R.S., to whom the author some time since submitted specimens, collected at various points in the year 1880.

From near Ballachulish, etc., a finely-banded, fine-grained micaceous schist, containing apparently a considerable amount of felspathic matter.

From Glen Spean, etc. Fine-grained gneisses, not rich in quartz, but with a considerable amount of black mica, not markedly foliated except as the result of subsequent pressure. All are characterized by a peculiar speckled aspect, the spots being about the size of pins' heads. The felspar varies from a warm to a reddish gray.

From Tyndrum, etc. A somewhat varying series of schists, but with a common facies. Some have but little mica, consisting mainly of quartz and felspar, and pale-gray or reddish in colour; others are very micaceous schists of a lead colour, with sheen surfaces and indications of mineral banding. There are also very quartzose gneisses of a white or pinkish-white colour.

Crianlarich and Killin, etc. Calc mica-schists, with sheen surfaces, due to subsequent pressure, but showing mineral banding. Also fine-grained gneisses like some of those near Tyndrum, but as they have a very marked cleavage foliation they may originally have been somewhat coarser grained. A garnetiferous mica-schist from several places.

Blair Athol, etc. Dark mica-schists, with rather a carbonaceous aspect, and a very marked cleavage foliation. Some show on close examination along the edges a speckled aspect, recalling some of the gneisses mentioned above. There is also a fairly coarsely crystalline limestone, with specks and streaks of green serpentinous material and some scattered pyrite; also a calc mica-schist, modified by pressure, and an important series of quartzose schists similar to those found at Tyndrum, etc.

To the south of this line, as mentioned by the author in another paper (Proceedings of the Geologists' Association, vol. vii. p. 84), "schistose and slaty chloritic rocks become more abundant in association with micaceous rocks," and "everywhere strongly recall to mind the pre-Cambrian rocks of Wales, especially those in Anglesea, and in the Lleyn Promontory." The author insisted that the term "Grampian" was the only suitable name for this group of pre-Cambrian rocks. It was suggested and adopted by him at a time when all these rocks were claimed by the Geological Survey as of Silurian age, and these rocks are nowhere in Britain so well exposed as in the Grampian mountains of Scotland.

II.—EARTHQUAKE PHENOMENA IN JAPAN. Twelfth Report. By PROF. JOHN MILNE, F.R.S., F.G.S.

1. *The Gray-Milne Seismograph.*

THE seismograph constructed in 1883—the expense of which was partly defrayed by the British Association—has during the last year given diagrams and records of Earthquakes, from number 1106 to number 1241.

2. *Report on Earthquakes felt in Japan in* 1888 *and* 1889.

In 1888 the number of Earthquakes recorded in Japan was 630, and the total land area shaken was 970,800 square miles. In 1889 the number of Earthquakes was 930, and the area shaken 1,048,200 square miles. On February 5th, 1888, an Earthquake shook 57,600 square miles. Some account is given of Earthquakes which preceded the eruption of Bandaisan, when within 10 minutes 28 square miles of a fertile valley were buried from 30 to 100 feet deep beneath a sea of earth and boulders. Everybody in the district perished. The damming up of the valley has formed a lake 8½ miles long.

On July 28th, 1889, an Earthquake took place in the Southern island. Twenty were killed and seventy-four wounded. All these Earthquakes have been classified with regard to hours, days, months, seasons, etc. They are also grouped according to intensity, direction, etc. It is clear that the vast amount of material which comes in yearly from the 700 stations of observation is capable of being analysed by methods other than those given. The Government Staff is insufficient to carry out more than their usual routine work. To carry it out privately requires access to documents and funds. The nature of new researches which might be made is indicated in the Report. At any moment all this valuable material bearing on Seismology accumulated in Japan, and of which there is no copy, may be lost by fire.

3. *Earth Pulsations.*

So far as the writer is aware, no attempt has been made to determine the character of the movements common to all countries usually called Earth Tremors. By using exceedingly light conical pendulums (made from a needle and a silk fibre)—the pointer being replaced by a small mirror reflecting a ray of light—the writer is inclined to the view that the earth-motions producing movements in this form of apparatus are not elastic vibrations such as might be produced by the beating of a steam hammer, but that they are long wave-like undulations like the swell on an ocean. During the time that these pulsations are continuing it is noticed that they have a definite direction. They are most frequent when the place of observation is crossed by a steep barometric gradient, whether there is wind or whether it is fine. The possible relationship of these movements to the escape of Fire Damp, the swinging of pendulums, etc., is discussed. The records of these phenomena have been photographed, and examples of them accompany the Report.

4. *The Overturning and Fracturing of Columns, Walls, etc.*

By continuing experiments on the overturning of columns when subjected to earthquake-like motion, we can now state with confidence the acceleration required to overturn any given column by its own inertia. In the experiments on fracturing, all the brick columns and walls snapped at their base. The form of column which when moved back and forth by an Earthquake will offer an equal resistance at all horizontal sections to the effects of its own inertia has been determined.

In ordinary engineering practice the cross-section of piers is practically uniform from the base upwards—short piers near a river bank have the same cross-section as long piers in the centre of the river, etc. A large series of piers for bridges now being built in Japan have been designed in accordance with the rules resulting from our experiments on fracturing.

5. *The Great Earthquake of October 28th,* 1891.

9,960 people were killed, 128,750 dwelling houses were totally destroyed, and in a few seconds Japan lost the equivalent of perhaps 30 million dollars. About twelve million dollars have already been poured into the district for repairs and relief. The movement reached Berlin at the rate of 9,800 feet per second. At Tokyo, 150 miles from the origin, the ground moved in long flat waves, which tilted the water in ponds and caused seismographs to act as angle measurers. These waves had a velocity of about eight feet per second. A few chimneys fell.

The origin was the formation of a fault which can be traced for 40 or 50 miles along the surface. Some 3,000 shocks have been recorded since the first great shock. Mountain slopes have been stripped by land slips, valleys are dammed up and lakes have been formed. Valleys have been compressed so that farms have decreased in area. 400 miles of river banks were shaken down or deeply crevassed. Mud volcanoes formed. Railway lines and bridges twisted and distorted. Foundations of bridges in one case were shifted 19 feet.

Some thousands of calculations respecting accelerations to produce fracturing and overturning have been made. Records of seismographs have been examined and the velocity of gravity and of elastic waves have been computed. The origin was in a non-volcanic district but where elevation was in progress. Earthquakes seldom originate from volcanoes, but they occur in volcanic countries where secular movements are in progress or where mountains are in process of formation.

A photographic record taken at each end of a water level several miles in length and if possible at right angles to an axis of elevation, might give measurements of slow tilting and throw light on a possible relationship between Earthquakes and these movements, etc. Such an experiment might cost £500.

Earthquake and Volcanic effects will, if possible, be illustrated by some very large photographs kindly *lent* by Prof. W. K. Burton.

The grant last year was £10, but at least three times this sum has been spent.

Before the end of this year, with the assistance of subscribers, I shall publish a Seismological Journal which will be uniform in character with the Transactions of the Seismological Society.

III.—FOSSIL ARCTIC PLANTS FOUND NEAR EDINBURGH. By CLEMENT REID, F.L.S., F.G.S.

RECENT discoveries by Mr. Bennie, of the Geological Survey, have brought to light a series of silted-up tarns or small lochs in the neighbourhood of Edinburgh. These tarns seem to have lain in irregular hollows left on the retreat of the ice, for the lowest deposits usually yield remains of arctic plants. The principal localities for these plants are Corstorphine and Hailes. Trees, except perhaps the alder, are entirely missing in the lower deposits, and the vegetation consists mainly of dwarf willow and birch, with a few herbaceous plants, of species still living within the Arctic Circle. The list now includes the following plants, those marked with an asterisk being arctic species no longer living in the lowlands of Scotland:—

Ranunculus aquatilis, Linn.
,, *repens*, Linn.
Viola (?).
Stellaria media, Cyr.
Rubus sp.
**Dryas octopetala*, Linn.
Potentilla sp.
Poterium sp.
Hippuris vulgaris, Linn.
Myriophyllum spicatum, Linn.
Taraxacum officinale, Web.
Andromeda Polifolia, Linn.
**Loiseleuria procumbens*, Desv.
Menyanthes trifoliata, Linn.
**Oxyria digyna*, Hill.
**Betula nana*, Linn.
Alnus (?).
Salix repens, Linn.
* ,, *herbacea*, Linn.
* ,, *polaris*, Wahlb.
* ,, *reticulata*, Linn.
Empetrum nigrum, Linn.
Potamogeton sp.
Eleocharis palustris, R. Br.
Scirpus pauciflorus, Lightf.
,, *lacustris*, Linn.
Carex, 2 sp.

IV.—DEVON AND CORNISH GRANITES. By W. A. E. USSHER, F.G.S.

FROM the relations of the stratified rocks to the granites of Devon and Cornwall there is no obtainable evidence as to the upheaval of the latter.

From evidences of great mechanical disturbance (such as deflections of strike and constrictions of outcrop), of metamorphism in areas bordering the granites, from the shapes, relative positions, and internal structure of the granite masses; from the distribution of the Elvans, and from evidences of the production of cleavage in the area prior to the contact metamorphism of the cleaved rocks, it appears that the sites of the Devon and Cornish granite masses were occupied by the granites or pre-existent and subterraneously connected rocks of pre-Devonian age, which had, in a rigid state, exercised an obstructive influence on the north and south movements, and had thereby produced great mechanical effects on the surrounding strata prior to the alteration of the latter.

The contact alteration of the stratified rocks seems to be coeval with the metamorphism of these ancient masses and the consequent genesis of the granites in their present form during the later stages, or at the close of the Carboniferous epoch. The intrusion of granitoid rocks perhaps accompanied, certainly succeeded, the solidification of the granites, and continued at intervals down to the Permian quartz porphyries. These rocks, called Elvan dykes, approximate, with some few exceptions (notably the north and south Elvan of Watergate Bay), to the general strike produced by the north and south movements, and in some cases, as near Camelford, to the main strike deflections produced by the resistance of granite masses to these movements, but in proceeding from granite to killas they ignore the slight uptilt of the latter on the margin of the granites.

The evidences in favour of the subterranean connection of the Devon and Cornish granites are too strong to be ignored, and this connection annihilates the application of the laccolitic hypothesis advanced by me to account for the relations of the Dartmoor granite, and at the same time contradicts the suggestion of the upheaval of the granites in or through their surroundings.

V.—On the Occurrence of *Chonetes Pratti*, Davidson, in the Carboniferous Rocks of Western Australia. By R. Bullen Newton, F.G.S., British Museum (Natural History).

IN this communication the author directed attention to some valves of a *Chonetes* recently discovered by Mr. Harry Page Woodward, F.G.S., in rocks of Carboniferous age situated in the Irwin River District of Western Australia, which he referred to *C. Pratti*, a species described and figured by the late Dr. Thomas Davidson in the "Geologist" for 1859, Plate IV, Figs. 9–12, p. 116. As the original description, contained only in the explanation of the plates, is necessarily somewhat brief and imperfect, the following additional characters were submitted:—

(1) That the external surface of both valves, besides being ornamented with very fine radiating striæ, possess subimbricating concentric lines of growth; (2) that the extent of the cardinal margin represents the minimum width of the shell; (3) that the granular asperites on the interiors of the valves are disposed in lines as they reach the margins, having more or less an elongate appearance resembling short tubular spines; (4) that the external surface of the ventral valve exhibits a number of small orifices placed at irregular distances, which are probably basal attachments of spines, a character known to exist in *Chonetes papilionacea*, *C. Hardrensis*, etc. The author then gave the dimensions of the Davidson type valves, together with those of the Western Australian specimens, the latter being somewhat larger. A minute examination of the Western Australian specimens and their comparison with the originals of *C. Pratti* in the Davidson collection at the British Museum has demonstrated the fact that they are mineralogically as well as structurally the same brachiopod. This fact is of considerable importance, as the Davidson specimens at the time of descrip-

ı were unlocalised, and the species, as far as can be ascertained, never been referred to since either by Davidson himself or any other writer up to the present time. There is very little ıbt that the new material from the Irwin River District yielded ↄ the Davidson types. The paper concluded with a small list of ·boniferous fossils collected in the same neighbourhood, which 'e been described and figured by Messrs. A. H. Foord and G. Hinde in the GEOLOGICAL MAGAZINE for 1890.

—THE FULLER'S EARTH MINING CO. AT WOBURN SANDS. By A. C. G. CAMERON, Geological Survey of England and Wales.

INCE reporting to the British Association in 1884 and 1891 on the progress made in working this mineral, the demand for it gone on steadily increasing, and mining on systematic principles been established in Bedfordshire for the first time. The mines r show an extensive industry, with underground galleries that end many hundreds of feet. The layers of earth as they come to worked are not found disposed quite evenly, but raised into slight ıualities, ridge-and-furrow-like. Although all one sort of earth, layers alternate in colour downwards, from yellow, through blue, yellow again; a difference in colour which Mr. Player, who analysed the Woburn earth, does not consider is explained by 'erence in composition.

:t has long since been suggested that the name "Woburn Sands" uld be applied to the lower portion of the Lower Greensand of Midlands, and the name may well be retained for Bedfordshire l Bucks. It is at Woburn Sands, in these counties, that the atest expanse and greatest thickness of Greensand occurs, and ere it contains also those valuable deposits of fuller's earth.

[.—NOTE ON A GREEN SAND IN THE LOWER GREENSAND, AND ON A GREEN SANDSTONE IN BEDFORDSHIRE. By A. C. G. CAMERON, Geological Survey of England and Wales.

HE beds in the section at the "Parish Sandpit" at Apsley Guise are given below in descending order:—

	Ft.	In.
1. Yellow and grey sand with strings of yellow fuller's earth ...	20	0
2. Lenticular seam yellow fuller's earth...	3 to 6	
3. Yellow and grey sand, in parts false-bedded	25	0
4. Yellow fuller's earth, dovetailed amongst green sand	2	0
5. Yellow ochre	0	2
6. Bright green sand 'hearted' darker green	2	6
7. Coarse, buff-coloured irony sand	1	8
Oxford Clay	54	10

[he bright green sand (No. 6), with a darker middle portion, .sists of irregular-shaped grains of quartz, stained green; besides ich, there are brown grains, the precise nature of which remains the present undetermined. With the hammer this sand gives a ›wn streak, the brown grains, which are comparatively soft, being cause of it. The absence of glauconite is a distinct feature in this sand, that being the usual colouring-matter of cretaceous green sands. A darker tint of green pervades the middle portion of the bed, giving it the appearance of being 'hearted,' as the expression goes. Rather over a mile from this place, Mr. Whitaker observed in the tower of Husborne Crawley Church a quantity of green sandstone of a bright colour, and sometimes of a glassy texture, which has been recognized as like some that occurs in the Lower Greensand of Ightham, Kent. It is a serviceable-looking stone, and the brightness of its colour adds beauty to the brown sandstone, of which the edifice is mainly built. The stone seems to be a counterpart of the green sand in the Apsley Section, and similarly colour-hearted. Professor Bonney, on receiving specimens of the Husborne Crawley rock, but speaking from sight only, doubts, however, whether it is the same as the green sand at Apsley. It may be mentioned that pieces of the same rock have been dug up in the roadway half a mile from the church, and a larger boulder-like piece lies by the roadside, on the outskirts of the village green. Adjoining the churchyard is a very old-looking excavation, that suggests the spot at which this stone may have been got. Seeing the difficulty of transporting stones in olden times, it is extremely unlikely that the stone came from a distance. Possibly, therefore, there may be some local equivalent of the Lower Greensand of Kent in the Bedfordshire Greensand, which, if not entirely dug away in supplying the stone for Crawley Church, may yet again be brought to light.

VIII.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, EDINBURGH, 1892.

Address to the Geological Section by Professor C. LAPWORTH, LL.D., F.R.S., F.G.S., President of the Section.

(PART II.)

In the structure of our modern mountain ranges we discover the most beautiful illustrations of the bending and folding of the rocky formations of the earth-crust. The early results of Rogers among the Alleghanies, and of Lory and Favre in the Western Alps, have been greatly extended of late years by the discoveries of Heim and Baltzer in the Central Alps, of Bertrand in Provence, of Margerie in Languedoc, of Dutton and his colleagues in the western ranges of America, and of Peach and Horne and others in the older rocks of Britain. The light these researches throw upon the phenomena of mountain structure will be found admirably summarised and discussed in the works of Leconte, of Dana, of Daubrée, of Reade, of Heim, and finally in the magnificent work of Suess, the 'Antlitz der Erde,' of which only the first two volumes have yet appeared.

Looking first at the mountain fold in its simplest form as that of a bent rock-plate composed of many layers, which has been forced into two similar arc-like forms, the convexities of which are turned, the one upwards and the other downwards, we find in the present mountain ranges of the globe every kind represented. We commence with one in which the arch is represented merely by a gentle swell in the rock sheet, and the trough by an answering shallow depression, the two shading into each other in an area of contrary flexure. From this type we pass insensibly to others in which we see that the sides of the common limb or septum are practically perpendicular. From these we pass to folds in which the twisted common limb or septum overhangs the vertical, and so on to that final extreme, where the arch limb has been pushed completely over on to the trough limb, and all three members, as in our note-book experiment, are practically welded into one conformable solid mass.

Although the movements of these mountain folds are slow and insensible, and only effected in the course of ages, so that little or no evidence of the actual movement of any single one of them has been detected since they were first studied, yet it is perfectly plain that when we regard them collectively, we have here crust folds in every stage of their existence. Each example in itself represents some one single stage in the lifetime of a single fold. They are simply crust folds of different ages. Some are, as it were, just born; others are in their earliest youth. Some have attained their majority, some are in the prime of life, and some are in the decrepit stages of old age. Finally, those in which all three members—arch limb, trough limb, and septum—are crushed together into a conformable mass, are dead. Their life of individual movement is over. If the earth pressure increases, the material which they have packed together may of course form a passive part of a later fold, but they themselves can move no more.

In many cases, due partly to the action of longitudinal pressures, the septum becomes reduced to a *plane* of contrary motion, namely—the over-fault, or thrust-plane, and the arch limb and the trough limb slide past each other as two solid masses. But here we have no longer a fold, but a fault.

We see that every mountain fold commences first as a gentle alternate elevation and depression of one or more of the component sheets of the geological formations which make up the earth-crust. This movement is due apparently to the tangential thrusts set up by the creeping together, as it were, of those neighbouring and more resistant parts of the earth-crust which lie in front of and behind the moving wave. Yielding slowly to these lateral thrusts, the crest of the fold rises higher and higher, the trough sinks lower and lower, the central common limb or septum grows more and more vertical, and becomes more and more strained, sheared, and twisted. As this middle limb yields, the rising arch part of the fold is forced gradually over on to the sinking trough part, until at last all three members come into conformable contact, and further folding as such is impossible. Movement ceases, the fold is dead. We see also from our note-book experiment that the final result of the completion of the fold is clearly to strengthen up and consolidate that part of the crust plate to the local weakness of which it actually owed its origin and position. The fold has, by its life-action, theoretically trebled the thickness of that part of the earth-plate in which its dead remains now lie. If the lateral pressure goes on increasing and the layers of the earth-crust again begin to fold in the same region, the inert remains of the first fold can only move as a passive part of a newer fold: either as a part of the new arch-limb, the new trough-limb, or the new septum. As each younger and younger fold formed in this way necessarily includes a more resistant, and therefore a thicker, broader, and deeper sheet of the earth-crust, we have here the phylogenetic evolution of a whole family of crust folds, each successive member of which is of a higher grade than its immediate predecessor.

But it very rarely happens that the continuous crust plate in which any fold is imbedded is able to resist the crust creep until the death of the first fold. Usually, long before the first simple fold is completed, a new and a parallel one rises in front of it, normally on the side of the trough limb, and the two grow, as it were, henceforward side by side. But the younger fold, being due to a greater pressure than the older, must of necessity be of a higher specific grade, and the two together form a generic fold in common.

Our present mountain systems are all constituted of several families of folds, formed in this way of different gradations of size, of different dates of origin, and of different stages of life evolution; and in each family group the members are related to each other by this natural genetic affinity.

Sometimes the new folds are formed in successive order on one side of the first fold, and then we have our unilateral (or so-called unsymmetrical) mountain groups, like those of the Jura and the Bavarian Alps. Sometimes they are formed on both sides of the original fold, and then we have our bilateral (or so-called symmetrical) ranges, like the Central Alps. In both cases the septa of the aged or dead folds of necessity all slope inwards towards the primary fold. If, therefore, they originate only on one side of the primary fold, our mountain group looks unsymmetrical, with a very steep side opposed to a gently sloping side. If they grow on both sides of the original fold, we have the well-known 'fan structure' of mountain ranges. In this latter case the whole complex range is seen at a glance it is a vast compound arch of the upper layers of the earth-crust, keyed up by the material of the dead or dying folds, which by the necessities of the case [illegible] mighty wedges whose [illegible] are directed inwards towards the centres of the system. But a compound arch of this kind is in reality not a single compound fold, but a double one, with a septum on both sides of it, and it requires two troughs, one on each side of it, as its natural double complement. The so-called unsymmetrical ranges, therefore, which are theoretically constituted merely of arch limb, trough limb, and septum, are really the more natural and the more common.

It is clear that in the lifetime of any single fold its period of greatest energy and most rapid movement must be that of middle life. In early youth and in old age the lateral pressure is applied at a very small angle, and the tangential forces act therefore under the most disadvantageous circumstances. But in the middle life of the fold the arch limb and the trough limb stand at right angles to the septum, and the work of deformation is then accomplished under the most favourable mechanical conditions and with the greatest rapidity. That is to say, the activity of the fold and the rate of movement of the septum, like the speed of the storm wind, varies directly as the gradient.

In our [illegible] experiment we observed that little or no change took place in the arch limb and trough limb, while the septum became remarkably sheared and twisted. The same is the case in nature, but here we have to recollect that these [illegible] mountain folds are of enormous size, indeed actual mountains in themselves. These great arches, scores of miles in length, thousands of feet in height and thickness, must of necessity be of enormous weight, capable of crushing to powder the hardest rocks over which they move, while the thrust which drives them forward is practically irresistible. It is plain, therefore, that while the great arch limb and the trough limb of one of these mighty folds move over and under each other from opposite directions, they form in combination an enormous machine, composed of two mighty rollers or millstones, which mangle, roll, tear, squeeze, and twist the rocky material of the middle limb or septum, which lies jammed in between them, into a [illegible] mass. This deformed material, which is the characteristic product of the mountain-making forces, is, of course, made up of the stuff or the original material of the fold; and whether we call it breccia, mylonite, phyllite, or schist, although it may be composed of sedimentary stuff, it is certainly no longer a sedimentary rock, and though it may have been originally purely igneous material, it is certainly no longer igneous. It is now a manufactured article made in the great earth-mill.

These mountain folds, however, are merely the types of folds and wrinkles of all dimensions which affect the rock formations of the earth crust. Within the mountain chains themselves we can follow them in lesser and lesser dimensions, [illegible] first down to formations, then to strata, then to laminæ, till they disappear at last in microscopic minuteness beyond the limits of ordinary vision. Leaving these, however, for the moment, let us travel rather in the opposite direction, for these mountain folds are by no means the largest known to the stratigraphical geologist. Look at any geological section crossing our own continent of North America, and it will be found that the whole of the Rocky Mountain range on its western side and the Alleghany range on the east are really two mighty compound geological anticlines, while the broad sag of the intermediate Mississippi basin is actually a compound geological syncline made up of the whole pile of the geological formations. That is to say, the continent of North America is composed of a pair of geological folds, the two arches of which are represented by the Rockies on the one side and the Alleghanies on the other, while the intermediate Mississippi syncline is the common property of both. Here, then, we reach a much higher grade of fold than the orographic or mountain-making fold, viz., the plateau-making fold or the semi-continental fold, which, because of its enormous breadth, must include a very much thicker portion of the earth-crust than the ordinary orographic fold itself.

But which must be the real middle limbs of these two American folds, the septal areas where most work is now being done and the motion is greatest?

Taught by what we have already learned of the mountain wave, the answer is immediate and certain. They must be on the steeper sides of each of the two folds, namely on those which face the ocean. How perfectly this agrees with the geological facts goes without saying. It is on the steep Pacific side of the western fold that the crushing and crumpling of its rocks is the greatest. It is on the Atlantic side of the eastern fold that the contortion and metamorphism of its rocks are at their maximum, while in the common and gently sloping trough of both folds, namely, in the intermediate Mississippi Valley, the entire geological sequence remains practically unmodified throughout.

Again, which of these two American folds should be the more active at the present day? Taught by our study of the mountain wave, the answer again is immediate and conclusive. It must be that fold whose septum has the steeper gradient. Geology and geography flash into combination. The steeper Pacific septum of the western fold from Cape Horn almost to Alaska is ablaze with volcanoes or creeping with earthquakes, while the gently inclined Atlantic septum of the eastern fold from Greenland to Magellan Straits shows none, except on the outer edge of the Antilles, in the very region where the slope of the surface is the steepest. We see at a glance that the vigour of these two great continental folds, like those of our mountain waves, varies directly as the surface gradient of the septum.

But the geographical surface of North America, considered as a whole, is in reality that of a double arch with a sag or common trough in the middle. We have seen already that this double arch, must be regarded as the natural complement of the equally double Atlantic trough. Here, then, if the path of analogy we have hitherto so triumphantly followed up to this point is still to guide us, the trough of the Atlantic must be, not only in appearance but in actuality, formed of two long minor folds of the same grade as the two that form the framework of America, but with their members arranged in reverse order. If so, their submarine septa ought also to be lines of movement and of volcanic action. And this is again the case. The volcanic islands of the Azores and St. Helena lie not exactly on the longitudinal crests of the mid-oceanic *Challenger* ridge, but upon its bounding flanks.

But we have not yet, however, finished with our simple folds. If we draw a line completely round the globe, crossing the Atlantic trough at its shallowest, between Cape Verde and Cape St. Roque, and continued in the direction of Japan, where the Pacific is at its deepest, we find that we have before us a crust fold of the very grandest order. We have one mighty continental arch stretching from Japan to Chili, broken submedially by the sag of the Atlantic trough; and we see that this great terrestrial arch stands directly opposed to its natural complement, the great trough of the Pacific, which is bent up in the middle by the mightiest of all the submarine buckles of the earth-crust, on which stand the oceanic islands of the central Pacific.

But if this be true, then the septum of all septa on our present earth-crust must cross our grandest earth fold where the very steepest gradient occurs along this line, and it must constitute the centre-point of the moving earth fold, and of greatest present volcanic activity. And where is this most sudden of all depression? Taught once more by our geological fold, the answer is instantaneous and incontrovertible. It is on the shores of Japan, the mightiest and most active of all the living and moving volcanic localities on the face of our globe.

But the course of the line which we indicated as forming our grandest terrestrial folds returns upon itself. It is an endless fold, an endless band, the common possession of two sciences. It is geological in origin, geographical in effect. It is the *wedding-ring* of geology and geography, uniting them at once and for ever in indissoluble union.

Such an endless fold again must have an endless septum, which, in the nature of things, must cross it twice. Need I point out to the merest tyro in these wedded sciences that if we unite the Old and New Worlds and Australia, with their intermediate sags of the Atlantic and Indian Oceans, as one imperial earth arch, and regard the unbroken watery expanse of the Pacific as its complementary depression, then the circular coastal band of contrary surface flexure between them should constitute the moving master septum of the earth's crust. This is the "Volcanic Girdle of the Pacific," our "Terrestrial Ring of Fire."

Or, finally, if we rather regard the compact arch of the Old World itself as the natural complement of the broken Indo-Pacific depression, then the most active and continuous septal band of the present day should divide them. Again our law asserts itself triumphantly. It is the great volcanic and earthquake band on which are strung the Festoon Islands of Western Asia;—the band of Mount St. Elias, the Aleutians, Kamtchatka, and the Kuriles;—the band of Fusijama, Krakatoa, and Sangir. The rate of movement of the earth's surface doubtless everywhere varies directly as the gradient.

We find, therefore, that even if we restrict our observations to the most simple and elementary conception of the rock fold as being made up of arch-limb, trough-limb, and twisting but still continuous septum, we are able to connect, in one unbroken chain, the minutest wrinkle of the finest lamina of a geological formation with the grandest geographical phenomena on the face of our globe.

We find, precisely as we anticipated, that the wave-like surface of the earth of the present day reflects in its entirety the wave-like arrangement of the geological formations below. On the land we find that the surface arches and troughs answer precisely to the grander regional anticlines and synclines of the subterranean sedimentary sequence; and it may, I believe, be regarded as certain that the submarine undulations have a similar or complementary relationship. We find in the New Geology, as Hutton found in the Old, that geography and geology are one. We find, as we suspected, that the physiognomy of the face of our globe is an unerring index of the solid personality beneath. It bears in its lineaments the characteristic family features and the common traits of its long line of geological ancestors.

Such, it seems to me, is an imperfect account of the introductory paragraphs of that great chapter in the New Geology now in course of interpretation by geologists of the present day; and we have translated them exactly in the old way by the aid of the only living geological language, namely, the language of present natural phenomena, and I doubt not that sooner or later the rest of this great chapter will be read by the same simple means.

I have strictly confined myself to-day to the discussion of the characteristics of the simple geological fold as reduced to its most elementary terms of arch, trough, and unbroken septum; for this being clearly understood, the rest naturally follows. But this twisted plate is really the key which opens the entire treasure-house of the *New Geology*, in which lie spread around in bewildering confusion facts, problems, and conclusions enough to keep the young geologist and other scientific men busily at work for many a long year to come.

Into this treasure-house I often wander myself, in the few leisure hours that I can steal from a very busy professional life; and out of it I bring now and again heresies that sometimes amuse and sometimes horrify my geological friends. As you have so patiently listened to what I have already said, perhaps you will permit me in a few final sentences to indicate in brief some of those novelties which I see already more or less clearly, and a few of those less novel points on which it appears to me that more light is wanted. My excuse is twofold, first, to furnish material for work and controversy to the young geologists; and second, to obtain aid for myself from workers in other walks of science.

The account of the simple rock-fold which I have already given you is of the most elementary kind. It presupposes merely the yielding to tangential pressure from front and back, combined with effectual resistance to sliding. But in the layers of the earth-crust there is always in addition a set of tangential pressures theoretically at right angles to this. The simple fold becomes a *folded fold*, and the compound septum twists not only vertically but laterally. On the surface of the globe the double set of longitudinal and transverse waves brought about in this way is everywhere apparent. They account for the detailed disposition of our lands and our waters, for our present coastal forms, for the direction, length, and disposition of our mountain-ranges, our seas, our plains, and lakes. The compound arch becomes a dome, its complementary trough becomes a basin. The elevations and depressions, major and minor, are usually twinned, like the twins of the mineralogist, the complementary parts being often inverted, and turned through 180° (compare Italy with the Po-Adriatic depression). Every upward swirl and eddy has its answering downward swirl. The whole surface of our globe is thus broken up into fairly continuous and paired masses, divided from each other by moving areas and lines of mountain making and crust movement, so that the surface of the earth of the present day seems to stand midway in its structure and appearance between the surfaces of the sun and the moon, its eddies wanting the mobility of those of the one and the symmetry of those of the other. In the geology of the earth-crust, also, the inter-crossing of the two sets of folds, theoretically at right angles to each other, gives rise to effects equally startling. It lies at the origin of the thrust-plane or overfault, where the septal region of contrary motion in the fold becomes reduced to, or is represented by, a *plane* of contrary motion. It allows us to connect together under one set of homologies folds and faults. The downthrow side of the fault answers to the trough, the upthrow side to the arch, of our longitudinal fold, while the fault-plane itself represents the septal area reduced to zero. The node of the fault, and the alternation and alteration of throw, are due to the effects of the transverse folding.

These transverse folds of different grades, which affect the various layers of the earth-crust differentially, account also for the formation of laccolites, of granitic cores, and of petrological provinces. They enable us also to understand many of the phenomena of metamorphism.

Of the folds of the *third order*, I shall here say nothing, but I must frankly admit that the primal cause of all this tangential movement and folding stress is still as mysterious to me as ever. I incline to think that the motion is due to many causes—to tidal action, to sedimentation, and many others. I cannot deny, however, that it may be *mainly* the result of the contraction in diameter of our earth, due to the loss of its original heat into outer space? For everywhere we find evidences of symmetrical crushing of the earth-crust by tangential stresses. Everywhere we find proofs that the various layers of that crust have been most affected differentially, and the outer layers have been bent the most. We seem to be dealing not so much with a solid globe as with a globular shell composed of many layers.

Is it not just possible after all that, as others have suggested, our earth is such a hollow shell, or series of concentric shells, on the surface of which gravity is at a maximum, and in whose deepest interior it is non-existent? May this not be so, also, in the case of the sun, through whose spot-eddies we possibly look into a hollow interior? If so, perhaps our present nebulæ may also be hollow shells formed of meteorites; on the surfaces of these shells the fiery spirals we see would be the swirls which answer to the many twisting crustal septa of the earth. Our comets, too, in this case might be elongated ellipsoids, whose visible parts would be merely interference phenomena, or sheets of differential movement.

In this case we have represented before us to-day the past of our earth as well as its present. Uniformity and Evolution are one.

Thus from the microscopic septa of the laminæ of the geological formations we pass outwards *in fact* to these moving septa of our globe, marked on the land by our new mountain chains, and on the shores by our active volcanoes. Thence we sweep, *in imagination*, to the fiery eddies of the sun, and thence to the glowing swirls of the nebulæ; and so outwards and upwards to that most glorious septum of all the visible creation, the radiant ring of the Milky Way.

Professor George Darwin, in his Address to the section of Mathematical and Physical Science at the meeting of the British Association at Birmingham in 1886, with all the courage of genius, and the authority of one of the sons of the prophets, acknowledged that it seems as likely that "meteorology and geology will pass the word of command to cosmical physics as the converse." Behind this generous admission I shelter myself. But I feel absolutely confident that long after the physicists may have swept away these astronomical suggestions as "the baseless fabric of a vision," there will still remain in the treasure-house of the geological fold a wealth of abundant material for the use of the mathematician, the physicist, the chemist, the mineralogist, and the astronomer, of the deepest interest and of the highest value.

NOTE.—The first Part of the above Address was set up inadvertently from an uncorrected proof. Most of its errors explain themselves, but for the sake of clearness, the reader should substitute the following for the corresponding paragraphs on pp. 420–421.

In the earlier days of geology one of the first points recognised by our stratigraphists was the fact that the formations were successive lithological sheets, whose truncated outcropping edges formed the present surface of the land, and that these sheets lay inclined at an angle one over the other, as William Smith quaintly expressed it, like a tilted 'pile of slices of bread and butter.' But as discovery progressed the explanation of this arrangement soon became evident. The formations revealed themselves as a series of what had originally been deposited as horizontal sheets, lying in regular order one over the other, but which had been subsequently bent up into alternating arches and troughs (*i.e.* the anticlines and synclines of the geologist), their visible parts, which now constitute the surface of our habitable lands, are simply those parts of the formations which are cut by the irregular plane of the present earth's surface. All those parts of the great arches and troughs formerly occurring above that plane have been removed by denudation ; all those parts below that plane lie buried still out of sight within the solid earth-crust.

Although in every geological section of sufficient extent it was seen that the anticline or arch never occurred without the syncline or trough—in other words, that there was never a rise without a corresponding fall of the stratum. Yet it is only of late years that the stratigraphical geologist has come clearly to recognize the fact that the anticline and syncline must be considered together, and must be united as a single crust-wave, for the arch is never present without its complementary trough, and the two together constitute the *tectonic*, *structural, or orographic unit*, namely, *The Fold*, the study of which, so brilliantly inaugurated by Heim in his "Mechanismus der Gebirgsbildung," is destined, I believe, in time, to give us the clue to the laws which rule in the local elevation and depression of the earth-crust, and furnish us with the means of discovery of the occult causes that lie at the source of those superficial irregularities which give to the face of our globe its variety, its beauty, and its habitability.—EDIT. GEOL. MAG.

REVIEWS.

EDINBURGH MUSEUM OF SCIENCE AND ART GUIDE TO THE GEOLOGICAL GALLERY. 8vo. Niel & Co., Edinburgh, and H. M. Stationery Office, 1892.

THE Science and Art Department having sanctioned the removal of the Collection made by the Geological Survey of Scotland, and its rearrangement in the Grand Museum of Science and Art in Edinburgh, it can now be most advantageously studied. An extensive gallery, the upper floor of the west wing, is devoted to the exhibition of minerals, rocks, and fossils, not only those collected by the Survey, but those given by Messrs. Dudgeon and Milne, Prof. Heddle, Dr. Wilson, and others, and illustrative of the structure and geological history of Scotland. The rock-specimens are arranged, together with the Geological Maps, as far as possible according to their respective Counties; and the rocks are most fully displayed under the district where they are most typically represented, with ample references, by means of numbers and otherwise, to the localities. Descriptive labels for the petrology, geology, and topography accompany the specimens. An index-collection of rock-types is also at hand for the use of students.

In the Guide here noticed, the order and contents of the cases illustrative of the petrological geology of the several Counties of Scotland are given in detail. The stratigraphical collection of Scottish Fossils is similarly treated, but not so fully: and the minerals are briefly noticed. Some geological models and photographs are also mentioned.

The Department of Science and Art has to be congratulated on the

excellent manner in which this new arrangement of the Geological Museum has been carried out, and on the praiseworthy attempt to give every possible opportunity and convenience for the study of Geology in the great Northern Capital.

CORRESPONDENCE.

THE MAMMOTH AND THE GLACIAL DRIFT.

Sir,—From the lofty heights of literary criticism Sir Henry Howorth looks down upon the struggling company of practical geologists, and seems to think that he gains a much better view of the problems to be solved than those who are toiling among the inequalities of the plain below.

The toilers on the plain, however, will be apt to think that they can perceive the structure of these inequalities better than the man who surveys them from such a distant standpoint, and when this person boldly proclaims from his mountain-top that the geologists are making great mistakes they will naturally ask him if he has ever taken a nearer view of the deposits he points to. Now it does not appear that Sir Henry Howorth has had any practical experience as a geologist; he evidently has a considerable acquaintance with the literature of Pleistocene geology, but geologists cannot accept this as a sufficient qualification for dealing with such a difficult subject as the relative ages of British Pleistocene deposits. His lack of practical acquaintance with the deposits he is writing about shows itself on page 400, where he quotes Prof. Flower's discovery of flint implements "at Thetford on the Ouse" as bearing on the age of the gravels in the valley of the Ouse near Bedford! Is it possible that from his lofty standpoint Norfolk and Bedfordshire seem close together?

It is of course perfectly logical to form a theory and then to see if it harmonises with the facts, but if he imagines that he has exhausted the data on which geologists ground their belief that some of the mammaliferous gravels are of later date than the East Anglian Boulder-clays, he is very much mistaken, and his claim to have proved that deposits containing the Mammoth fauna are *never underlain* by Glacial Drift is simply preposterous.

To disprove a universal negative a single case is of course sufficient, and he actually quotes such a case without recognizing it as such. This is the section near Burgh, in Lincolnshire, where gravel with mammalian bones is intercalated between two sheets of Boulder-clay, the lower bed or "marl" being really the main mass of Boulder-clay. Whether my description of the locality fails to make this clear to the reader I cannot say, for I have not a copy of the memoir with me in the country.

I believe, too, though here I do not speak from personal knowledge, that there is no doubt about the superposition of the brick-earth at Hoxne. Mr. H. B. Woodward distinctly states that the section he saw in 1878 had chalky Boulder-clay beneath it,[1] though

[1] Geology of England and Wales, 1887, p. 515.

he admits that small pockets of such clay were also seen above it. Why does Sir Henry Howorth only quote the latter statement and not the former?

If Sir Henry will study the facts in the field, and especially if he will have a few excavations made at any of the localities where the relative age of the beds is doubtful, he will earn the gratitude of geologists, but his present methods of controversy do not entitle him to their respect.

There is an excellent field for research at Brandon; it is easy to prove that some of the brick-earths pass under the Boulder-clay, but there still remain two points to be decided, (1) do such brick-earths contain flint implements? (2) are there not other deposits containing flint implements and mammalian remains which rest on this Boulder-clay?

Let Sir Henry Howorth do for Geology what General Pitt-Rivers has done for Archæology, and we will welcome the results. Meantime any further endeavour to support a preconceived theory by a partial examination of written statements will hardly be welcome to readers of this Magazine.

September 5th, 1892. A. J. Jukes-Browne.

SHAPES OF SAND GRAINS.

Sir,—It is pleasant to hear from so experienced an observer as Mr. Cecil Carus-Wilson that the views expressed in my paper on Glacial Geology on the generally superior roundness of Marine Sands as compared with river sands are borne out by his own independent observations.

My remarks on the rounding of sand grains were strictly limited to its bearing on glacial geology. The sand-dunes referred to were those of our own coast. Here from Crosby to Southport we have 23 square miles of Blown sand which I have been living on and working in as an engineer for the last 25 years. I can find no detectable difference in form between the sand grains of the shore and those of the dunes.

Desert sands are of course out of the question in glacial geology, and I quite agree with Mr. Carus-Wilson's observations relative to them. His other interesting observations shall have my attention in future work.

I have found my sand investigations of the greatest use in glacial geology, though not originally undertaken for that purpose. The polish in some of the glacio-marine sand grains is quite remarkable. No glacial *shelly* sands that I have examined fail to show much rounding of the grains—not only those quartz but the undoubted glacially derived materials also. There are also other glacial *shelless* sands of which there are the most convincing evidences of marine origin that exhibit equal evidences of extreme attrition.

The non-marine but purely glacial sands are invariably angular. I have just received from Professor J. J. Stevenson, of New York, a sample of sand from Glacier Bay in front of the Muir Glacier, Alaska, which is remarkably angular in grain.

e all instruments of research, this one of shape must be used
common sense and the surrounding circumstances taken into
leration, but when as on Moel Tryfaen extremely rounded and
ed grains of quartz are found amongst a great mass of very
ar material they may be treated as erratics. No rock in the
bourhood could yield them, and to the educated eye they at
proclaim their sea-origin, whatever mode of transit may be
tically provided for them according to the proclivities of the
gist.

m glad of the opportunity of reiterating these views first
ht forward in a paper recently read before the Geological
y.

T. Mellard Reade.

Corner, Blundellsands, *Sept. 7th*, 1892.

THE ROCKS OF SOUTH DEVON.

,—Now that Mr. A. R. Hunt's three-months-long dissertation
Devonian Rocks of South Devon has come to an end, I may
pace for a very few words, as I do not intend to discuss the
t in detail.

attaches importance to mineral coincidences between the
s and the admitted Devonian rocks. Some of these, such as the
res, seem to me very much of a Monmouth-Macedon type;
to be more naturally explained by supposing that the latter
derived some of their materials from the former or a kindred
lline group, an alternative which seems to me inadequately
sed in his paper.

I have always held that the dark mica-schists were once
ents, as the Devonian phyllites have been, and I have never
d the possibility that some of the green chlorite-schists
ally might have been basic igneous rocks, parts of Mr. Hunt's
nents do not affect my position.

m Mr. Hunt's paper I infer that he is not aware that a schist,
crushing (particularly if dark in colour), is sometimes very
lt to distinguish from a much-squeezed dark slate; also that
other crushed crystalline rocks simulate squeezed grits. The
lties are local, and generally can be overcome when you know
to look for, but they are so real that I always hesitate to
ss an opinion on microscopic slides when I have not seen the
n the field, and even then, once or twice, when the outcrops
scanty, have been unable to come to a conclusion.

have never denied that what it is now the fashion to call
nometamorphism has greatly modified both the schists and the
nian rocks, but, in calling attention to it, I pointed out that the
t "went into the mill" as schists, the other as clays. I do
d that Mr. Hunt has adequately discussed this very important
r.

ring the nine years which have elapsed since my paper was
n, I have many times examined both my own and other
nens from South Devon, and have had unusual opportunities of
ing, in other regions, similar rocks and some sections which

were very helpful in illustrating those of the Start district. So, with a greatly enlarged experience, both in the field and with the microscope, I could now improve my former paper (*e.g.* I could amend the accounts of the "chloritic" rocks; should be more ready to recognise altered basic igneous rocks among them; should say that the mineral, very doubtfully identified with kyanite, and some of the smaller grains of water-clear mineral—thought then to be quartz—were more probably secondary felspars), but I should express myself, if possible, yet more confidently as to the distinction in lithological characters and geological age of the two groups of rocks, the schists and the slaty Devonian system.

Mr. Hunt, so far as I can judge from internal evidence, has had little experience in dealing with problems such as that which he attempts—perhaps the most difficult presented to petrologists. Possibly his experience may be commensurate with my own, but till I have reason to believe that he has studied such problems in other fields than South Devon, and has ample materials at his command for the necessary research, I must decline to do more than say that my original opinion is not in any way altered by his dissertation.

T. G. Bonney.

"CONE-IN-CONE STRUCTURE."

Sir,—In the September Number of the Geological Magazine there is a note by W. S. Gresley, on "Cone-in-cone Structure," in which he refers to "Mr. John Young's theory of how the rock was formed." With your kind permission, I beg to state, that I have no "*theory*" on the above subject, and in connection with the explanations that I have given of the cone structure in my paper,[1] the word "theory" is never used in any of my own explanations, but it will be found on p. 25, where I give the opinion of Professor Newberry, who there uses the word "theory" in connection with cone formation, "and the upward escape of gases through a pasty medium." Regarding its formation, all the explanations that I have ventured to give are founded upon what is revealed in the best preserved, and most illustrative specimens of the cone structure that I have found in the carboniferous strata of the West of Scotland, and, I do not think, that in these explanations of the various points of structure, that I have stated anything beyond what the specimens themselves most clearly reveal. I have, in various parts of my paper, pointed out that there are structures which have been referred to "cone-in-cone," but which present appearances so dissimilar to those noticed in my paper, that to them my explanations do not apply, stating, that they will each "have to be described with reference to their external characters and internal structures."

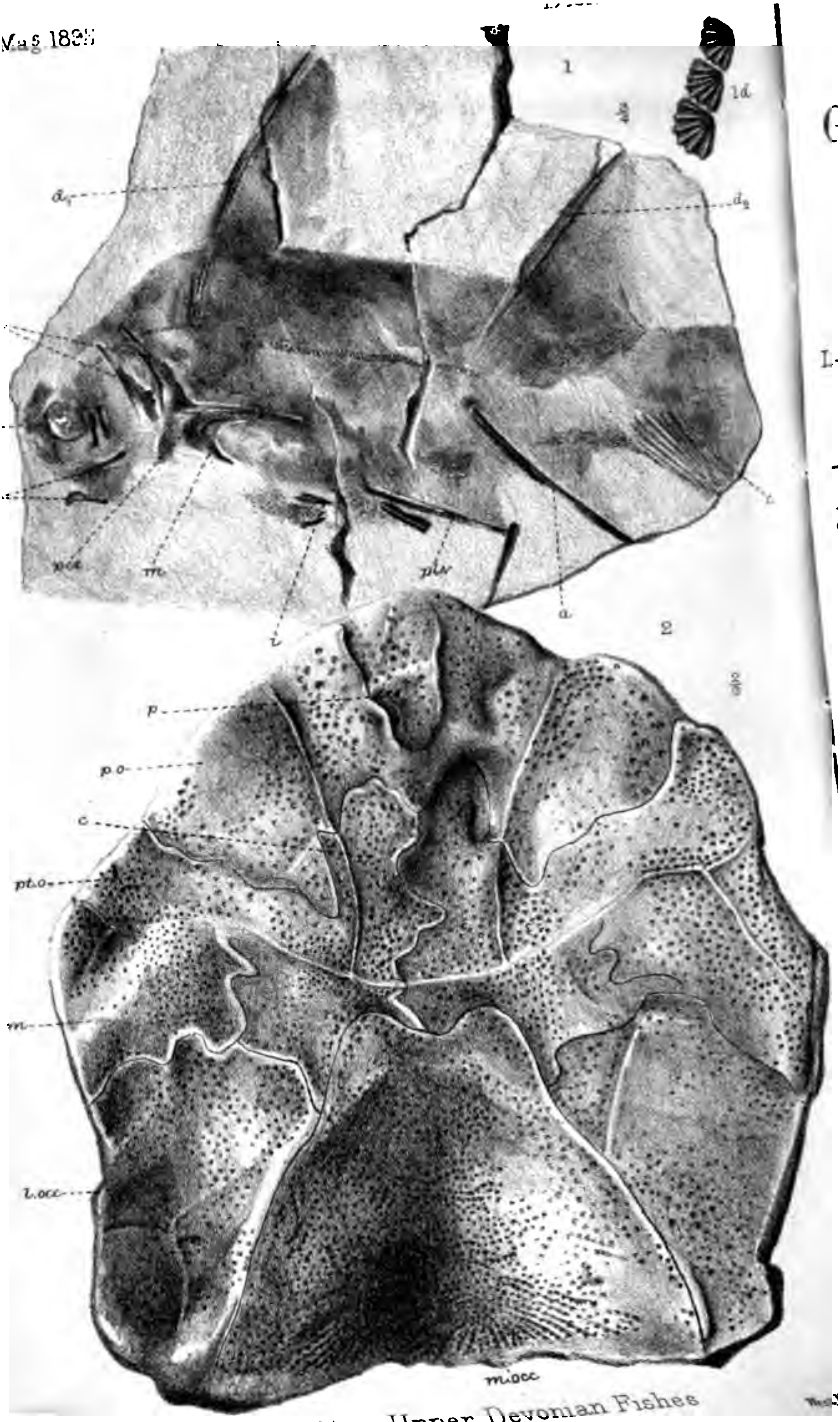
John Young, F.G.S.

Hunterian Museum, University, Glasgow.

---

[1] Trans. Geol. Soc. Glasgow, vol. viii.

Mag 1892



Canadian Upper Devonian Fishes

dward del et lith

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IX.

No. XI.—NOVEMBER, 1892.

ORIGINAL ARTICLES.

I.—Further Contributions to Knowledge of the Devonian Fish-fauna of Canada.

By Arthur Smith Woodward, F.L.S., F.G.S.

(PLATE XIII.)

EARLY in the year the present writer published some notes on the Lower Devonian Fishes of Campbellton, New Brunswick, collected by Mr. Jex in the summer of 1891.[1] Since that date the remainder of the collection, comprising a very large series of specimens from the Upper Devonian of Scaumenac Bay, in the Province of Quebec, has been acquired by the British Museum; and materials are thus forthcoming for some further observations.

I. On the Body-armour of *Phlyctænaspis acadica*.

Before, however, proceeding to a consideration of the fishes of the Upper Devonian, a few additional examples of *Phlyctænaspis* from Campbellton are worthy of brief note, in reference to the body-armour. The presence of a number of plates, much resembling those of the ordinary *Coccosteus*, has already been determined by Whiteaves;[2] the median dorsal and the ventro-lateral plates being especially similar. It is also evident, from certain of the new specimens (Brit. Mus., Nos. P. 6574–75), that the body-armour in *Phlyctænaspis* is articulated with the head-shield by means of a boss on each anterior dorso-lateral plate, exactly as in *Coccosteus*. There are, nevertheless, certain small plates that cannot be placed with reference to the last-named familiar genus; and it is not unlikely that some of these—notably the symmetrical, ridged examples—will prove to occur on the otherwise unarmoured tail.

But the most striking feature in the body-armour of *Phlyctænaspis*, now shown for the first time, is the presence of a pair of fixed spines, each apposed in the greater part of its extent to a lateral plate of the trunk (Fig. 1). These spines are robust but hollow, compressed, very slightly arched, tapering at both ends, and marked with irregular longitudinal series of tubercles. They are, indeed, precisely similar in external form and appearance to those of

---

[1] Smith Woodward, "On the Lower Devonian Fish-Fauna of Campbellton, New Brunswick," Geol. Mag. Dec. III. Vol. VIII. pp. 1–6, Pl. I. (1892).

[2] J. F. Whiteaves, "Illustrations of the Fossil Fishes of the Devonian Rocks of Canada, Part I.," Trans. Roy. Soc. Canada, vol. vi. sect. iv. pp. 94, 95, pl. ix. (1888).

Acanthaspis;[1] and so far as can be judged from known specimens, they only differ from the last-mentioned spines in the circumstance, that the supporting plate is destitute of the extended oblique pedicle observed both in the type specimens from the Corniferous Limestone of Ohio and in the shield assigned to the same genus from Spitzbergen.[2] It thus remains to discover more associated examples of the plates and spines from Ohio, to determine whether they actually pertain to Ostracoderms, as suspected, or whether they represent part of the armour characteristic of Arthrodira; for the fixed spinous appendage is now proved to occur in both of these widely separated groups.

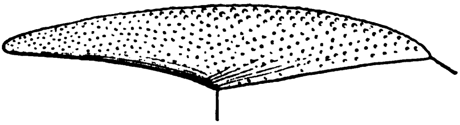


FIG. 1.—Spinous appendage of dermal armour of *Phlyctænaspis acadica.*

II. NEW SPECIES FROM THE UPPER DEVONIAN, SCAUMENAC BAY.

The fossils from Scaumenac Bay comprise numerous fine examples of the known species of *Bothriolepis*, *Acanthodes*, *Phaneropleuron*, *Eusthenopteron*, and *Cheirolepis*. Among them there are also remains of two additional genera, hitherto not discovered in Canada; and the best of these specimens are shown in Plate XIII. One genus is the Acanthodian *Diplacanthus*, only known previously from the Lower Old Red Sandstone of Scotland; the other is *Coccosteus*, of very wide range in the Old Red Sandstone, both as regards time and space.

Diplacanthus horridus, sp. nov. [Plate XIII. Fig. 1.]

Sp. Char.—A species of moderate size, attaining a length of not less than 0·12; the greatest depth of the trunk contained about four times in the total length of the fish. Fin-spines much elongated, with one deep longitudinal sulcus parallel to the anterior margin, and the sides either smooth or very finely striated. [Pectoral fin-spines incompletely known]: median pectorals conspicuous, close to the former; pelvic fin-spines relatively large, about equalling the anal fin-spine in size. Dorsal fin-spines very large and elongated, the length of the first much exceeding the depth of the trunk at its point of insertion, equalling the length of the space between the two dorsal fin-spines, and larger than the second fin-spine, which is directly opposed to the anal fin-spine, and equals the latter in size. Scales marked with prominent radiating furrows and ridges; those of the lateral line in the abdominal region slightly enlarged.

Specimens.—This species is determined on the evidence of two specimens, of which the type, in counterpart, is shown of three-quarters the natural size in Pl. XIII. Fig. 1. The head and extremity of the tail are imperfect in both specimens, and the pectoral fins are only fragmentary; but otherwise the general form and proportions of the fish are well shown.

---

[1] J. S. Newberry, "Fishes of the Devonian System," Geol. Surv. Ohio, vol. ii. pt. ii. p. 36 (1875).

[2] Smith Woodward, "The Devonian Fish-Fauna of Spitzbergen," Ann. Mag. Nat. Hist. [6] vol. viii. p. 4, pl. i. (1891).

In the head the large dermal tesseræ on the cranial roof, and part of the narrow ring round the orbit (*orb.*), are exhibited by both specimens; and there is a pair of small elements postero-inferiorly (*s.*), each with a triangular expansion at one end, a contraction mesially, and a less expansion at the other end, probably representing the "styliform bone." Behind the orbit in the type specimen, there is also evidence of a vertically-elongated, superficially-calcified cartilage, apparently the hyomandibular. The ascending portion of the scapular arch (*x.*) is distinct behind the head; and in the type-specimen one of the median spines (*m.*) is well shown immediately within the base of the pectoral fin-spine (*pct.*). The intermediate ventral spines (*i.*) are well developed and exhibited in both specimens; and the very large pelvic fin-spines (*plv.*) also occur in both. All the median fin-spines are more or less fractured, though their proportions are satisfactorily indicated (d_1. d_2. *a.*); and in the type specimen the fin-membrane is seen to extend to the extremity of the spine in the two dorsals. All the fin-spines exhibit a single deep groove close to and parallel with their anterior border; and the lateral face behind this groove is feebly marked with longitudinal striations, especially in the anal fin of the second specimen. The caudal fin (*c.*) shows the ordinary Acanthodian characters, and there are traces of the robust, calcified hæmal arches of the axial skeleton at the base of its lower lobe. The scales (Fig. 1*a*) are very conspicuously ornamented, and the slight enlargement of the two rows of scales bordering the lateral line in the abdominal region is distinct in both specimens.

Affinities.—The species thus indicated belongs to the genus *Diplacanthus*, as defined in the British Museum Catalogue (Pt. II. p. 23), and differs notably from the most closely allied species, *D. longispinus*, in the very large size of the median fin-spines, and in their relative dimensions as noted in the diagnosis.

Coccosteus canadensis, sp. nov. [Plate XIII. Fig. 2.]

This species as yet is not satisfactorily definable, being known only by a weathered beach-pebble exhibiting an impression of the head-shield. The features shown, however, suffice to readily distinguish this shield from all described forms except the typical *Coccosteus decipiens*; and from the head-shield of the latter it evidently differs (i) in its greater length as compared with the breadth, (ii) in the narrower median occipital, and (iii) in the relatively smaller size of the central plates.

Almost the whole of the border of the shield is destroyed, but most of the sutures and the sensory canals are distinctly exhibited in impression. The median occipital plate (*m. occ.*) is considerably more than twice as broad behind as in front, and its superficial tuberculations are arranged in radiating series towards the posterior border. The lateral occipital (*l. occ.*), marginal (*m.*), preorbital (*p. o.*), postorbital (*pt. o.*), and pineal (*p.*) plates are imperfect and do not require special note; while the central plates (*c.*) form a relatively small and not quite symmetrical pair. The sensory canals of each side are distinctly united in the usual manner by a transverse commissure across the central plates; and it may be added that the white mark on the lateral occipital of the right side in the drawing is an indication merely of a fracture.

Coccosteus is already well known to occur in the typical Upper Old Red Sandstone; and it is interesting to note that in Russia, as in Canada, the genus is found in association with species of *Bothriolepis*.

III. On the Supposed Jaws of *Bothriolepis*.

In the new collection the British Museum acquires many fine examples of *Bothriolepis*, some displaying features not hitherto observed; but the most striking specimens are two exhibiting the supposed jaws.

It has long been known that a pair of loose, narrow plates occurs on the inferior face of the head in the Asterolepidæ. These plates were interpreted by Pander,[1] as the two rami of the lower jaw; and they are placed by Traquair[2] in juxtaposition with the anterior border of the ventral body-shield as "mental plates," of uncertain, though possibly mandibular function. By Whiteaves,[3] however, the pair of elements in *Bothriolepis* is represented as immediately adjoining the front margin of the dorsal shield, while the space for the mouth occurs behind. It is the latter interpretation that now proves to be correct, and a diagrammatic sketch of the parts in the critical specimen (No. P. 6761) is given in the accompanying Woodcut, Fig. 2.

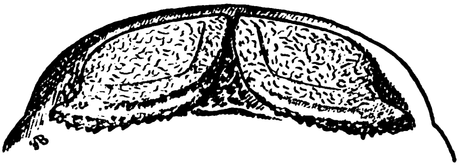


Fig. 2.—Supposed jaw-plates of *Bothriolepis canadensis*.

This drawing, it will be observed, agrees well with that of the corresponding parts already given by Whiteaves (*loc. cit.* pl. vii.) merely adding some important details. In all the specimens of *Bothriolepis canadensis* in which the present writer has been able to examine the plates in question, they occur in close apposition to the anterior margin of the head-shield as here shown; and it is noteworthy that there are traces of an excavation of the short externo-lateral margin of each of these plates, as if providing space for a pair of nasal openings at the antero-lateral angles of the snout. Mesially, the plates taper somewhat to the symphysis, being in this respect unlike those of *Pterichthys*; and the free posterior border is convexly arched. The greater part of the outer face of each plate is feebly rugose and marked by a sharply bent sensory canal; but there is a conspicuous smooth band immediately adjoining the posterior border, and this is further remarkable for exhibiting an irregular series of minute sharp denticles different in aspect from the bosses and points of the ordinary surface ornament. It appears, indeed, as if the pair of plates in question formed the anterior margin of the mouth, covered with an overlapping lip of soft tissue and provided with a minute denticulation. It still remains to be determined, however, in what manner a jaw of this form can have worked; and the opposing hard parts, if any, have yet to be discovered.

---

[1] C. H. Pander, "Die Placodermen des Devonischen Systems," p. 49 (1857).

[2] R. H. Traquair, "On the Structure and Classification of the Asterolepidæ," Ann. Mag. Nat. Hist. [6] vol. ii. p. 488, pl. xvii. fig. 2 (1888).

[3] Trans. Roy. Soc. Canada, vol. iv. sect. iv. pl. vii. (1886).

It may be added that internal to these jaw-plates in one specimen (P. 6762), there occurs the very thin lamina of smooth bone already noted by Whiteaves (*loc. cit.* 1886, p. 103); and its straight hinder margin is shown across the space at the symphysis in the drawing, Fig. 2. This is evidently an internal bone, but it is difficult even to hazard a suggestion as to its homologies and function; and the interpretation of the element must be deferred until the discovery of still more satisfactory specimens.

EXPLANATION OF PLATE XIII.

UPPER DEVONIAN FISHES FROM SCAUMENAC BAY, PROVINCE OF QUEBEC, CANADA.

FIG. 1. *Diplacanthus horridus*, sp. nov.; lateral aspect of fish, three-quarters natural size. *a.* anal fin-spines; *c.* caudal fin; d_1, d_2. first and second dorsal fin-spines; *i.* intermediate ventral spines; *m.* median pectoral spine; *orb.* orbit; *pct.* pectoral fin-spine; *plv.* pelvic fin-spine; *s.* styliform bones; *x.* pectoral arch. [Brit. Mus., No. P. 6756.]

FIG. 1*a*. Scales of ditto, much enlarged.

FIG. 2. *Coccosteus canadensis*, sp. nov.; impression of external aspect of head-shield, two-thirds natural size. *c.* central plates; *l.occ.* lateral occipital; *m.* marginal; *m.occ.* median occipital; *p.* pineal; *p.o.* pre-orbital; *pt.o.* post-orbital. [Brit. Mus., No. P. 6755.]

II.—ON PORPHYRITIC QUARTZ IN BASIC IGNEOUS ROCKS.

By ALFRED HARKER, M.A., F.G.S.

[Read before the British Association, Section C, Edinburgh Meeting.]

ALTHOUGH the old-fashioned ideas as to the association of different minerals held by Breithaupt and others have been found to require much modification, there are still certain rules which hold with a high degree of generality. They are, indeed, merely consequences of the principle that the most important of the factors which determine the mineralogical constitution of an igneous rock, is the chemical composition of the magma from which it is formed. Roughly speaking, we may say that original free silica and acid silicates occur characteristically in acid rocks, more basic silicates in basic rocks. The striking exceptions are few and of comparatively rare occurrence. Thus the iron-olivine fayalite, the most basic of all rock-forming silicates, has been shown to exist in certain highly acid lavas, but it is known from two or three localities only. The case we have chosen for discussion is the exact opposite of this, *viz.* the occasional presence of free silica in rocks of thoroughly basic composition.

Olivine-basalts containing porphyritic quartz have been described by the American petrologists from California, Arizona, New Mexico, and Colorado, and similar cases have been noticed by others in places as widely separated as Arran, Madagascar, and the Korea. The typical manner of occurrence of the quartz is in small, more or less rounded grains, coated with a thin layer or shell of a greenish colour. This shell is ascribed to corrosion of the quartz-grain by the molten magma in which it was enveloped; it consists for the most part of minute crystals or granules of augite, sometimes of hornblende probably pseudomorphous after augite. Except for this shell, the quartz-grains closely resemble the corroded porphyritic quartz of many quartz-porphyries.

There is, however, another group of basic and sub-basic rocks which enclose porphyritic quartz much more commonly than the basalts do, *viz.* the peculiar group of the lamprophyres (minettes, kersantites, etc.). The little grains here have the same character as in the preceding case, and are surrounded by a similar augite-shell. They are known in the lamprophyre dykes of the Harz, Spessart, Dresden, and other places, and are beautifully exhibited in the North of England, *e.g.* in the dykes which cut the Lower Palæozoic inliers of Edenside and Teesdale.

The explanation adopted by most writers is that the enclosed grains of quartz represent fragments mechanically caught up by the magma in its passage through solid rocks during the process of intrusion. Such foreign fragments are undoubtedly met with in these as in other intrusive rocks, but to suppose that more than a small proportion of the recorded cases is to be explained in this way raises obvious difficulties. On this hypothesis we should expect intrusive rocks other than lamprophyres in the same districts to carry as frequently similar fragments; we should look to find in the neighbourhood some rock from which the grains of quartz might be derived; and we should expect the grains to occur with a local distribution in the dykes which enclose them. The theory fails in these respects, and a closer examination of the grains themselves proves conclusively that they are original constituents of the rocks in which they are found. In the first place they never have the shape of fragments. Whenever the corrosion has not entirely obliterated the original form, the outlines of the hexagonal pyramid are clearly discernible. Nextly, the grains are never composite, but always optically uniform throughout their extent. Thirdly, they contain no inclusions except rare crystals of zircon, apatite, or some other mineral of early separation, and glass-cavities, presenting thus a marked contrast to the quartz of granite or gneiss and to the great bulk of the grains in sandstones and grits. To these points of evidence, collectively very strong, others might be added. Thus, in the lamprophyres of the North of England, and apparently of some other districts, the quartz-grains are accompanied by various acid felspars. These never have the form of fragments, but of perfect crystals rounded by corrosion, and they are to be matched, not in any rocks broken through by the dykes, but in more acid rocks contemporaneous and cognate with the lamprophyres.

Diller and Iddings, clearly recognizing in the case of the American basalts the primary nature of the quartz, have supposed that this mineral separated out at an early stage from a magma having the composition of the rock in which the grains occur. Petrologists in general will, I think, be slow to admit the possibility of this. The last-named geologist[1] has pointed out that crystallization in an igneous magma may be modified by many conditions—the presence of water, variations of temperature and pressure, etc.—the effects of which we cannot always foresee; but it may fairly be objected that, if all these factors were of much importance, we should never find two specimens of igneous rocks alike. The *exceptional* nature of the phenomenon to be explained seems to preclude such general considerations.

A quite different and perhaps more plausible explanation of the presence of quartz-grains in basic rocks is suggested by an hypothesis which has recently attained some prominence in geological speculation. I refer to the conception of a large body of molten rock-material becoming separated by gravity into strata of different densities, the upper and lighter layers being the more acid, the lower and heavier more basic in composition. Postulating such a divided magma, we obtain a clue to the cognate origin of acid and basic rocks in many areas of igneous intrusion. There is another consideration essential to our argument. It seems to be established that crystals of quartz and felspar are not only denser than the magma which gives birth to them, but also denser than magmas of much more basic composition. If, then, we suppose quartz to crystallize out in the upper acid portion of a stratified magma-basin at an early stage, when the magma is still quite fluid, we see that the crystals must sink into the lower basic layers of the heterogeneous mass.

Our theory is, then, that the quartz was crystallized out, not in the basic rock in which it now occurs, but in a magma of acid composition which once overlay the basic; so that the quartz-grains scattered through our lamprophyre dykes had precisely the same origin as the quartz-crystals in the accompanying dykes of quartz-porphyry. The grains indeed differ from the crystals only in their more advanced stage of corrosion, due to the more basic nature of the enveloping magma. This process of corrosion, however, need not have taken place in the original magma-basin, and it is more probably assigned to a later time, when the great pressure was relieved, and the rocks were injected into their present position.

These ideas, suggested by a study of our north-country rocks, will probably be found to apply to the lamprophyres of other districts, and may throw light also on the problem of the origin of quartz-bearing basalts. It is noteworthy that in the districts where these various abnormal quartz-bearing types occur, the association of igneous rocks of very different chemical compositions and the order of their succession lead us, on quite independent grounds, to the hypothesis of the stratified magma-basin.

---

[1] J. P. Iddings, Amer. Journ. Sci. (3) vol. xxxvi. p. 208 (1888).

III.—NOTE ON THE LITHOPHYSES IN OBSIDIAN OF THE ROCCHE ROSSE, LIPARI.[1]

By H. J. JOHNSTON-LAVIS, M.D., M.R.C.S., F.G.S.

IT is a pretty well recognized fact that Obsidian is a *hydrous* silicate of indefinite composition and your fusion experiments confirm that fact. Now molten obsidian may give off its H_2O in consequence of two processes—by simple vesiculation, or by the individualization from the glass of a definite *anhydrous* silicate. More commonly these two processes have gone on together, but modified by the vicissitudes of temperature that the molten aquiferous glass is exposed to during its eruption.

A free surface is alike favourable to the separation of a gas from solution, and to the starting of crystallization. Crystallization may start from a vesicle (as I could show you at this present moment in a specimen of ice) or vesicles will form on the surface of crystals.

A spherulite, however, usually starts from some solid particle, as a microlith or a grain of dust enclosed in the glass, and proceeds to grow *outwards* in a radiating manner, but as it grows it liberates some vapour by the conversion of the hydrous glass to an anhydrous felspar; and likewise the spherulite acts, when the pressure is diminishing, as a catalytic or free surface, and simple vesiculation takes place.

The crystallization vapour will collect between the outer ends of the fibres, press them apart, and be joined by its ally the vesiculation vapour. The result is that they form a spherical vapour shell around the spherulite. The highly viscous glass (as proved by faulting in it) draws with it the outer ends of the radiating needles forming the greater part of the spherulite, with the exception of the most resisting part or parts on one or more sides which carries with it the central remnants of the spherulitic concretion as shewn in your figure 3. The spherulite may have broken up into a number of cones scattered over the interior of the vesicle-walls where they are attached by their bases. At the same time the sides of the cones have shrunk by the crystallization of the remaining glass between the component needles and the escape of the similarly enclosed vapour which would cause contraction in a lateral direction, so that the cones would tend to become more acute. Crystallization at the centre of the spherulite would be fairly complete, but as growth took place the supersaturation of the surrounding glass would tend to cause much of such glass to remain between the fibres unindividualized; the outer surface fibres would again jam tight on account of the relief of solution-tension by vesiculation. Thus there would be more interfibrillar glass in the middle zone and more contraction in that region when the spherulite breaks up. The chief cause, however, of the concave sides to many of the cones is that they are sectionized obliquely, and assume the concave-sided look through the microscope and an appreciable thickness of the section.

---

[1] Prof. G. A. T. Cole and Mr. G. W. Butler, the authors of a recent paper "On the Lithophyses in the Obsidian of the Rocche Rosse, Lipari" (Q.J.G.S. August, 1892), having found that Dr. Johnston-Lavis had been led to an interpretation of the facts considered, different from theirs, and hitherto unpublished, asked him to add to the discussion of the matter a brief abstract of his views. In accordance with his suggestion, his reply is here published.—EDIT. GEOL. MAG.

After vesiculation, growth continues normal to the vesicle wall and therefore no longer parallel with the fibres of the conical wedge, hence the mushroom or fan-like appearance.

Sometimes this wedge or cone is pushed into the glass by the expanding vapour behind it, as in your fig. 3.

You will see that I differ from you in holding that not only large part, but all of the felspar needles have developed *from within outwards*.

Of course I consider that tridimite, fayalite, magnetite, haematite, are true sublimates. If spherulites assume large size they become lithophysal for a second, third, and so on, spherical shells of vapour form around the new shell of spherulitic matter, and repeat a similar process to what occurred in the nucleus. Your figures are very good and characteristic. I interpret them as follows:—

Fig. 1.—Rapid and intense vesiculation around very small spherulites, which in the upper cavity have grown out a little, having for the most part been reduced to fine dust spread over the bubble walls. In the other vesicles the expansion and cooling was so rapid that no further growth could take place from the minute cones attached to the walls.

Fig. 2.—Well shows the broken-up cones and the difference in their circumference curve and that of the enlarged vesicle and the independent direction of the new formed fibres.

Fig. 3.—Shows one cone holding remains of nucleus of spherulite. It has been pushed into the wall of the vesicle by the expansion of the vapours on the opposite side.

Fig. 4.—Shows the union of one vesicle around several spherulites.

These phenomena occur only where expansion can take place from slight pressure.

The difference between my interpretation and yours seems to lie essentially in this—that your paper explains the universal association, in your specimens of cavities and spherulitic growths, as due to great part at any rate of these growths in the Lipari Obsidians having been *initiated* by the formation of steam vesicles; while I hold that such association may be attributed—(1) to the liberation of steam *during* crystallization; and (2) to the fact that the crystalline aggregates (spherulites) *when formed* would afford surfaces favourable to the disengagement of gas from the surrounding glass.

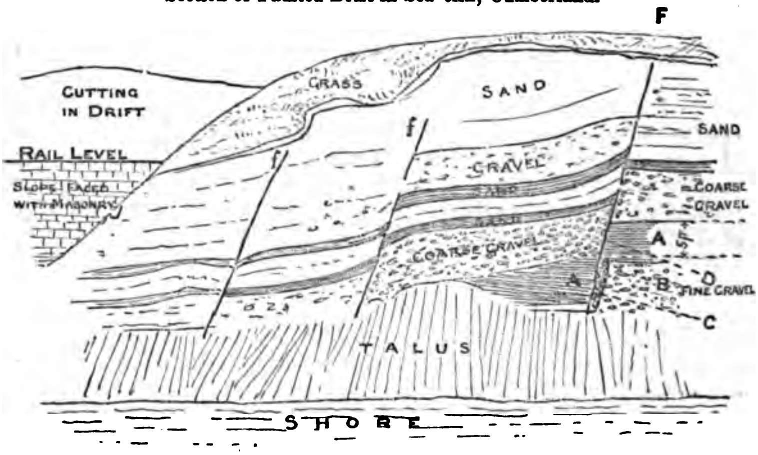
It is not only towards the *surface* of the Rocche Rosse lava stream that the spherulites are plentiful, and this I consider to be opposed to your interpretation. I hope soon to be able to show you some basic spherulites of another character, which also throw light on the subject.

IV.—FAULTING IN DRIFT.

By T. MELLARD READE, C.E., F.G.S., F.R.I.B.A.

In the GEOLOGICAL MAGAZINE of last year[1] I described a system of Miniature Faulting observed by me in a fine bed of banded silty clay at Nevin, Carnarvonshire. This year I have had the good fortune to observe Faulting in Drift on a much larger scale in the neighbourhood of St. Bees, Cumberland, which is highly instructive and explanatory of several features of Normal Faulting which the other illustration did not touch.

Section of Faulted Drift in Sea-cliff, Cumberland.



A. A. BED OF LAMINATED SAND DISPLACED 5 FT BY FAULT F.

The Faulted Drift in question, as exhibited in the sketch, is exposed in a sea-cliff section South of Nethertown Station. It consists of various beds of gravels and sand, some of the latter being well laminated. The faulting occurs at the northern end of the section. It consists of one main fault (*F*) at right angles to the shore, and two other smaller and parallel faults (*ff*) stepped down to the north of it. In consequence of the sharp shearing of the beds, I was enabled to measure the throw, and found that the laminated sand $A = A$ on opposite sides of the fault showed a throw of five feet. The hade of the fault, which was at about the angle shown on the sketch, was to the down-throw, and the beds were turned up against the fault on the down-throw side. Not only so, but the gravel on the plane of the fault (*D*) was turned up with the long axes of the stones parallel to the hade. The distinction between the gravel and the laminated sand where they abutted on each other on the fault-plane was as sharp as if the beds had been cut with a knife. In the case of the bed of fine gravel (*B*), the fault showed very prominently as the gravel projected some inches from the face of the cliff in a band about three inches wide (*C*) in which the pebbles were arranged with their long axes nearly vertical and parallel to the fault-plane, just like the fault-rock in more coherent material. The faulting is no doubt confined to the drift, and does not affect the bed rock, which is Permian sandstone.

---

[1] "A Miniature Illustration of Normal Faulting," GEOL. MAG. Nov. 1891, p. 487.

Its cause was not obvious, and it was raining so hard at the time that I had no opportunity of making extended observations. The Drift has adjusted itself to different conditions of space from that in which it was laid down; but the chief lesson to be learned is the *mode* in which this adjustment usually takes place, *i.e.*, by shearing, even where the material is of so incoherent a nature as gravel and sand.

V.—GLACIAL GEOLOGY, OLD AND NEW.

By PERCY F. KENDALL, F.G.S.,
Lecturer on Geology at Yorkshire College, Leeds.

THE recent contribution of Mr. Reade to Glacial Geology (GEOL. MAG. July, 1892, p. 310, *et seq.*) is a challenge which I take up in default of a worthier champion.

The origin of the drift deposits of Lancashire is not a question of sand-grains. Mr. Reade's observations upon those objects are a useful continuation of the work of the late John Arthur Phillips, but their bearing upon the rival theories is admittedly very remote. If the sand-grains are of directly marine origin (which is by no means certain, for the author makes no mention of derivation from the New Red Sandstone) they are just what one would expect in association with sea shells on either hypothesis.

Instead of the discussion of such rather irrelevant topics, Mr. Reade should give us a clear exposition of his views regarding 1. The sequence of events in Britain during Glacial times. 2. The limits of the submerged areas. 3. The sources of the glaciers which gave origin to the icebergs carrying *e.g.* the Criffel granite to Moel Tryfaen. 4. Mode of origin of Boulder-clay, especially of the intensely hard Till utterly devoid of stratification which is sometimes met with. 5. The mode of production of the striæ found so commonly on the rock-surfaces. 6. The mode of origin of the "ground-moraine" which he has described. 7. The distribution of life in his supposititious glacial sea. One or two of these could perhaps be conveniently discussed in the pages of the GEOLOGICAL MAGAZINE, but to deal with the whole of them with a detailed disquisition upon Gloppa, Moel Tryfaen, etc., would require that the Editor, whose obliging spirit is so well known, should lease his journal and editorial chair to the Glacialists for a couple of years, and allow them to bring out as many double numbers as they pleased. I would remind Mr. Reade of the proverbial disproportion between the time required respectively for questions and for answers, a disproportion intensified when the questioner possesses the ability of Mr. Reade. I will address myself to two points, and, having stated the facts so far as I can ascertain them by personal observation and by reading all the literature available to me, I will offer a few words by way of contrasting the different theories advanced to account for the phenomena. I purpose dealing, firstly, with the distribution of erratics in Lancashire, Cheshire, and the adjacent counties, and secondly, with the nature and distribution of molluscan remains found in the Anglo-Welsh Drift.

I. *The Distribution of Erratics.*

The erratics of the region I have selected are divisible into two tolerably well-defined groups—

a. Stones of foreign origin.

b. Stones of demonstrably local origin.

The former category includes the Granitic Rocks, Lavas, and ashes of the *Western side* of the Lake District, with a few stragglers from the Eastern side, such as the odd boulder of Shap granite found by Mr. Reade on Moel Tryfaen, and the sparse trail of blocks of the same rock traced by Mackintosh, Tiddeman, De Rance, and others, from the angle of Morecambe Bay in a curved line round *via* Longridge to Whalley. It also includes numerous examples of the granites, grits, and other well-marked types of rock found in Galloway and the neighbourhood of Criffel. Some half-dozen pebbles have also been recorded by Mr. Lomas of the remarkable Eurite of Ailsa Craig.[1] Flints also occur co-extensively with the other foreign rocks, and it has been assumed that they are necessarily of Irish origin, but from the fact that they are almost invariably of small size and much waterworn, I long ago inferred that they were immediately derived from some bed of river-gravel which had lain in the path of the ice which brought them into Lancashire. Whether their more remote origin was in Antrim, in the submarine extension of the Antrim Chalk, or in some other submerged outcrop of chalk, such as that which Mr. Goodchild supposes to exist at the mouth of the Solway Frith, matters not at all. If they come from a river-gravel the precise spot whence they were derived is immaterial.

With this enumeration the list of foreign rocks is completed. It is true that Dr. Hatch[2] thinks he has recognized Dolerites from Mull! but he gives no special locality in Mull, and from an extensive experience of Mull rocks I have no hesitation in saying that it is utterly futile to attempt a generic diagnosis.

Petrographers should remember the Anglesea Picrite and beware of confident identification of basic or ultrabasic Igneous rocks.

Near the mouth of the Vale of Llangollen, and thence south eastward, Welsh rocks make their appearance, and of these and of their peculiar distribution due account must be taken.

This mere cataloguing gives no idea of the *grouping* of the boulders, a subject which has apparently received less of Mr. Reade's attention than it deserves. The careful surveys made by Messrs. Lomas, Dwerryhouse, Platt,[1] Mackintosh, and others, bring out very clearly the great preponderance of Lake District rocks on the eastern side of the area and of Scottish rocks on the western side.

---

[1] Brit. Assoc. Report, 1892. See also Proc. Manch. Lit. & Phil. Soc. Feb. 1891.

[2] Brit. Assoc. Report, 1890, and Morton's Geol. of Liverpool, 2nd edition.

The transport of local stones is easy of definition over the major part of the area. There is a small number of rocks in South Lancashire and Cheshire whose outcrops are so restricted that peculiarities of their distribution can be studied with great facility. I take three examples.

1. Thin Permian Limestones, crowded with *Bakevellia*, crop out along the northern edge of the great Permo-Triassic basin near Leigh and Patricroft, Lancashire. Boulders of the rock are found at Stickins Island, on the Manchester Ship Canal. Another outcrop runs through Manchester-Salford, and boulders appear on the eastern side. A third outcrop has been discovered in the neighbourhood of Stockport, and again to the eastward boulders of the rock appear in the Drift deposits. I personally drew the attention of a party of the Liverpool Geological Society to the Manchester Ship Canal specimens, and one and all declared they had never seen such a rock in the Liverpool district.

2. In the Upper Coal-measures of the Manchester Coalfield, peculiar limestones crowded with *Spirorbis* occur. The outcrops are very restricted, but run in a N. and S. line, down to about Heaton Chapel, near Manchester. Now, not only have we (and Mr. Reade is amongst the observers) seen in a long, open section streams of boulders trailing away through the Boulder-clay to the eastward from each outcrop, but sporadic boulders have been found at Apethorne Mill, Hyde; at Buckley's Mill, Woodley, and at Glossop. Not one scrap has been found to the northward or westward of the parent mass.

The Millstone-grit boulders display the same peculiarities. In the Liverpool district admirable work is being done in the mapping of Boulders, and in the report on Erratic Blocks presented to the Edinburgh meeting of the British Association, a series of upwards of 400, being *all* those visible along several miles of the Mersey shore-line, has been recorded by Messrs. Lomas and Dwerryhouse, and among them there is not a single block of Millstone-grit. A similar list for the Rochdale area, by Mr. Platt, shows a very high percentage of boulders of that rock. In my own experience in south Lancashire and Cheshire I have met with but two, viz., one in Manchester (Denmark Road), and one at Portwood, Stockport.

What is the reason for this very partial distribution? The "anti-submerger" would point to the fact that the ice-movement has been from the N.W., and that whereas to the N.W. of Hale Head there is no Millstone-grit above sea-level, there is a very large outcrop of the rock to the N.W. of Rochdale.

These and other cognate facts were in my mind when I declared in a paper quoted by Dr. Crosskey, in the 18th Report of the British Association Committee on Erratic Blocks: "Boulders in this district never occur either to the N. or W. of the parent rock. . . . . It is, I believe, the law of boulder-transport for south Lancashire and Cheshire." This statement has never been traversed, and Mr. Reade has nothing to urge against it except his vague and contradictory theory of the transport of the material of the Drift in the direction of the existing drainage. (By the way, how does Mr. Reade account for the Weaver producing the Widnes clays, which are in the valley of the Mersey several miles *above* its confluence with the Weaver?)

---

[1] Brit. Assoc. Report on Erratic Blocks, 1890–92.

The facts given above may, I think, be best explained by supposing that a great lobe of ice came in from the Irish Sea, pushed over the low grounds of Lancashire, Cheshire, and Shropshire, and had its final melting place in the neighbourhood of Bridgenorth and Wolverhampton, where an amazing profusion of northern rocks—the "overshot load" of Mackintosh—and great piles of gravel and sand mark its termination. Upon its left flank, in the upper part of its course it was confluent with ice coming from the Lake District, and along the line of composition the thin trail of Shap Granite before alluded to is scattered. To the southward of Bacup it followed a line sub-parallel with the Pennine axis, which, however, it never crossed. On the right flank it rested against the outer line of hills of the great Welsh cluster, Halkin Mountain, Hope Mountain, Frondeg, and Gloppa.

Within the area thus roughly defined, *all* the indications point to a movement in the direction I have mentioned, saving only the few boulders of which Mr. Reade speaks as indicating a movement *from*, not *to*, the S.E. I deal with them later. The striæ exhibit a uniformity of direction surprising even to the advocates of the ice-sheet theory. In agreement with them is the orientation of large boulders, the direction of their sharper ends, the directions of Crag and Tail, the "forced arrangement" of boulders, the transport of local boulders, terminal curvature, and even, as Mr. De Rance, and later, Mr. Strahan, has remarked, the false-bedding of the Drift sands and gravels.

Mr. Reade, will hardly need to be reminded that such uniformity is not a characteristic of transport by tidal or drift currents, such as must be the main agents in the propulsion of icebergs.

Now, to consider the supposed cases of reversal of the direction of transport:—If we eliminate the flints, which, in the complete absence of evidence to the contrary, I can as well say came from the N.W., as Mr. Reade can assign to a south-easterly source, there remain some *eleven* exceptions to the "law," several of which are not in the area at all, and regarding nearly the whole of which, without any special pleading, it may safely be said that they are at least as likely to conform to the rule as not.

Of the eleven we have Lias accounting for four, viz.: "Lias" at Woollerton, Shropshire, "Lias" at Gloppa, "Lias Gryphites" near Ludlow, and broken Liassic fossils near Wolverhampton. Now, besides the known, though imperfectly mapped patch of Lias near Market Drayton, there is an outcrop in the north, near Carlisle, and before these exceptions can be accepted as valid, it must be shown that neither the one nor the other could have yielded them. Of the Liassic Gault and Chalk fossils recorded from Gloppa Mr. Nicholson found one Liassic fossil himself, while the remainder were obtained from the workmen.

We are told that Mr. Nicholson "has no reason to doubt their genuineness." I fancy there are very few geologists who will share this confidence in the accuracy of the British navvy. The gangs are recruited from all parts of the country, they have a great aptitude for turning a penny, and the way they carry specimens from one job to another is matter of notoriety; but, by way of illustration, I will mention two out of many cases within my own experience. At Moel Tryfaen I was offered a West Indian *Pyrula*, and several other obviously recent shells, by a workman, who protested that he had found them in the famous Drift deposits; and in the cutting of the Levenshulme railway, when I asked an intelligent ganger if he had found any shells in the Boulder-clay, he produced from his pocket two well-preserved specimens, *Fusus bulbiformis* and *Turritella sulcifera!* Need I say that I should want better evidence before I could admit the occurrence of the Gault *Inoceramus concentricus* in the Gloppa gravels. It is not surprising that Mr. Nicholson, in his maiden effort, of which he has such good cause to be proud, should manifest a willingness to accept the testimony of the navvy, but in a geologist of Mr. Reade's experience such credulity is wonderful. Let me ask Mr. Reade how he would get Gault fossils (from the condition of the specimen I should say it came from the Cambridge Greensand) round and *up* to Gloppa by the agency of floating ice? The twists and doubles would need to be of a very complicated description, and when they were all performed a vertical rise of close upon 1000 feet would have to be effected.

The "exceptions" have now nearly reached the irreducible minimum by this process of elimination, but I must whittle them down a little farther. The coal at Corwen found by Mr. Mackintosh must be accepted by all who know anything of the work of that most conscientious and painstaking observer. But, though I unreservedly accept the fact, I must demur to the inference that the coal came from Ruabon. Up the Vale of Llangollen, though I have found a round dozen of moraines of a glacier which came down the Vale, neither I, nor, so far as I can learn from his writings, Mr. Mackintosh ever found the slightest trace of any movement or of any transport up the Vale from Ruabon in the direction of Corwen. I am writing away from my books and papers, and therefore do not speak positively upon the point, but I have some recollection of seeing plant-remains in the state of coal which were found by Dr. Hicks in the slates at Corwen. If this be the case it would suggest a much more probable origin for the coaly fragments than Ruabon.

The occurrence of *Waldheimia obovata* at Wellington is avouched by Dr. Callaway, and therefore is inexpugnable; by the ice-sheet theory, however, there is still an explanation without calling in the aid of a capping of Oolite in the Liassic basin of Market Drayton. The central cross valley of England through which the Trent runs was the site, according to Lewis, of a large extra-morainic lake, produced by the obstruction by glacier-ice of the lower part of the Trent valley; another such obstruction, it appears probable, headed back the lower reaches of the Severn (upon this point I have formed no definite opinion), and the area of this lake was everywhere characterized in Lewis's words by a "commingling of the drift;" hence the Charnwood rocks at Nottingham, the Oolitic rocks at Shiffnal, the flints at Hanbury Woodend, and, perhaps, by the overflow of such a lake, the *Waldheimia* at Wellington. (I might add, too, for Mr. Reade's assistance in studying the problems, the Red Chalk recorded by Mr. Lucy in his paper on the "Gravels of the Severn, Avon, and Evenlode," and by Buckland in an earlier paper.) There remains now *one* errant erratic to be noticed, viz. the pre-Cambrian rocks of the Wrekin, found by Mr. Reade "immediately to the north of the Wrekin." Mr. Reade should here be a little more explicit regarding his solitary piece of good evidence. What pre-Cambrian rock is it? In what sense does he use the word "immediately"? If the rock be a volcanic (Uriconian) one, then I would point out that the pre-Cambrian lavas extend some distance to the northward of the Wrekin; on the other hand, the granitoid rocks (Malvernian) do not occur in the Wrekin at all. When Mr. Reade answers these questions it will be time enough to decide whether of the eleven cases of abnormal transport there is, or is not, just one which is inexplicable on the ice-sheet hypothesis.

If this solitary exception will really stand criticism, I still think that until it is reinforced by a good many other examples in other parts of the north-west it can hardly justify us in postulating the submergence of about half the land area of the British Isles. I would far rather call in the aid of melting snows upon the steep flanks of Ercal itself than take so great a liberty with physical geography to effect so small a result.

Can Mr. Reade not recall from his twenty years' experience of the Drift round Liverpool (my Drift experience is barely five years old) a few, nay even one, good and authentic illustration of a S. to N. transport of a boulder? Has he never found so much as one unmistakable erratic, say, for example, the Penmaenmaur Diorite, or the granitic rock of Yr Eifl?

I now come to the consideration of the second class of evidence, viz.:

II. *The Nature and Distribution of the Molluscan Remains found in the Anglo-Welsh Drift.*

I have carefully investigated every recorded occurrence of marine shells in the Drift deposits of South Britain, and I find not a single exception to the rule that they lie directly in the course of ice which, by all the physical indications such as striæ, transport of boulders, and the like, can be shown to have come in upon the land from seaward.

It follows from this that all shelly drift should contain what may be called "transmarine" erratics. Two cases were recorded where there was a default of evidence on this point or an explicit declaration of their absence. In the first case (Gloppa) foreign stones had but to be looked for to be found in profusion, and in the second case (Whalley),[1] where "obscure shell fragments" were recorded, a very short search sufficed to find foreign stones in the very same pit, and boulders, large and small, of Scottish and Cumbrian rocks were in evidence in many places in the neighbourhood. It is an exceptional thing to find any considerable deposit of Drift in the course of the great Irish Sea glacier, which is destitute of shells or shell fragments.

These are the positive facts of distribution. Now I would dwell a little on the negative evidence. I am duly mindful of the treacherous nature of negative evidence, but when able and industrious observers in all parts of the country have been assiduously searching for half a century or more, and have not brought forward one contradictory fact, I shall scarcely be accused of rashness if I lay some stress upon this failure.

If our country had been submerged to a depth of 1350 feet, it is surely not too much to ask why there are no shell-beds in the secluded mountain valleys in the great hill-clusters.

The fewness of the exposures, a reason assigned by Mr. Reade, cannot be taken as a very satisfactory explanation. If there are not so many gravel-pits or brickfields there are more mines and quarries, and the streams cut deeper and show cleaner sections; but, after all, it is not solely a question of shells, there should be beaches and cliffs, but where are they?

When we consider, again, the *condition* of the shells what do we find? The shells are comminuted and pounded in such a fashion that one may work for hours even in some of the most prolific beds and not find a perfect shell of any sort, and, astounding fact, in the 20,000 square miles or so of recently elevated sea-bottom in Lancashire, Cheshire, and the Drift-covered areas to the south, a bivalve with the valves in apposition has never been found, unless we admit as exceptions Mr. Nicholson's Gault *Inoceramus* and the *Saxicava* found in a bored boulder.

It might, too, be pointed out that we have no record of a single stone or shell being found encrusted with barnacles, and of the *two* bored stones recorded from the Boulder-clay of the area in question one was distinctly glaciated,[2] and the other, which formed the subject of a paper by Mr. Shone, had the crypts filled, not with the surrounding Boulder-clay, but with a fine sand very rich in microzoa, which is without its like amongst the Drift deposits of the district. Mr. Shone was led by this fortunate find to investigate the contents of univalves, and discovered that many of those found in the Boulder-clay contained a similar rich sand. He offered an explanation, which however ingenious, still fails to account for the total absence of any similar deposit on a larger scale. Scratched shell fragments are fairly common, and it is worthy of note that sub-perfect univalves are much more common than bivalves in equally good condition. The relative perfection of shells at high- and at low-levels respectively has been stated in the following very misleading terms (GEOL.

---

[1] See Geol. Surv. Memoir of the country round Burnley.

[2] "Nature," vol. xl. p. 246.

Mag. July, 1892, p. 312): "More perfect shells have been found at these high levels, especially at Gloppa, by Mr. Nicholson, F.G.S., than are generally met with in the Drift of the plains."

The plain English of this is "at certain selected localities at high-levels the shells are better preserved than in the average of low-level deposits." As a matter of fact, the low-level deposits include Leyland, which has yielded the largest list of shells ever compiled from an English or Welsh Drift-bed, and in point of mere numbers, I would undertake to collect more shells in an hour at Shellag Point, Isle of Man, than Mr. Reade could in a day at Gloppa, or a month at Moel Tryfaen. But as a matter of fact, there is, in the N.W. of England, no such thing as a glacial shell-*bed*. Anyone coming fresh from the old sea-beaches and sea-bottoms of East Anglia would, I doubt not, regard with astonishment the contents of these so-called marine deposits.

I turn now to the consideration of the nature of the fauna, and any remarks of a general nature which I may make must be taken to apply solely to the country to the westward of the Pennine Chain.

The shells throughout the whole area are, I consider, such as could not have existed in British Seas during the Glacial period. Mr. Reade, many years ago, remarked that the post-Glacial beds of the Clyde contained a fauna much more indicative of severe conditions than that contained in the Drift of the North-west of England. The fauna is not only an inconsistent one in respect of the mixture of shells of diverse habitat, warm-water and cold-water forms, sand and rock-haunting species with mud-loving forms, but, as Forbes pointed out 46 years ago, there is *an utter absence of deep-water fauna*. He says[1] "That in no case, so far as I have examined, the upheaved strata were formed under conditions of considerable depth, such as my *region of deep-sea corals* [50 fathoms to beyond 100] now presents, is rendered almost certain by the total absence of the remains of the characteristic inhabitants of that region." Again, "So far as I have seen, there is no British case of an upheaved stratum containing organic remains evidently untransported which may not have been formed at a less depth than 25 fathoms . . . . and it is probable that between 10 and 15 fathoms would more frequently approach the truth."

Mr. Reade has repeatedly commented upon the general similarity of the faunæ, and on p. 312 of the paper I am criticizing, he says—"These sands and gravels [*i.e.* at 1000–1400 feet above the sea-level] contain shells of mollusca, speaking generally, of a similar *facies* to those fragments found in the low-level Boulder-clay and sands." (The "fragments" is refreshing.) Now has Mr. Reade ever considered that with a submergence of 1400 feet there would have been a depth of *two hundred and thirty-three fathoms* over the low grounds of Lancashire, and will he be bold enough to say that *Turritella terebra, Purpura lapillus, Tellina balthica*, and *Cardium edule*, form the natural assemblage of shells which one should find *on a muddy bottom in* 200 *fathoms of water*?

---

[1] Mem. Geol. Survey, vol. i. p. 376.

The attempt to explain away the occurrence of southern forms by such remarks as that *Cytherea chione* is the only one of "anything approaching a wide distribution," is in the first place hardly correct, as *Arca lactea* has been repeatedly found; but, if it were, it is a very damaging admission. *Cytherea chione* is most distinctly a southern shell, and though it occurs in Carnarvon Bay I have heard of but two examples being found, viz.: one dredged by Mr. MacAndrew, many years ago, and the other, by myself, in a very "dead" condition. The statement that "some Tertiary shells are now only boreal in their habitat, notably *Tellina calcarea*," and the footnote quotation from Jeffreys, "Occurs in every Tertiary bed up to the Red Crag," reveals one of the dangers to which the geologists of the north-west are peculiarly liable. They are out of reach of any Tertiary beds except the Pleistocene, and hence are compelled to take some of their geology, when it relates to Tertiaries, as well as their conchology, from Jeffreys.

The only way in which Jeffreys' assertion could be made to square with the facts is to turn the geological succession upside down; then, and then only, could one say that *Tellina calcarea* occurs in every Tertiary bed *up* to the Red Crag.

I say, without fear of contradiction, that it does not occur *below* the Red Crag, and that even its occurrence in that deposit is very questionable. For my own part I do not admit the identity of *T. calcarea* and the Red Crag *T. pretenuis*. Furthermore, I assert, and challenge refutation, that a large portion of the Tertiary Period, to wit, the latter part of the Red Crag and subsequent Tertiary times, including the Chillesford and Forest Bed epochs, were characterized by a climate distinctly "colder than the present." Mr. Reade holds a contrary view, but I am satisfied that he is singular in his opinion.

It remains now for me to notice the most remarkable of all the shells of the Drift, viz., the extinct species. These have not received the attention they deserve, as the temptation is so great to "locate" a species as nearly as one can, instead of laboriously hunting out its precise affinities. Strange to say, Edward Forbes in this way overlooked the most remarkable shell in the Manx drift, viz., *Nassa reticosa*, Sow. (=*N. serrata*, Broc.), which he identified as "*Buccinum undatum* var., resembling *Nassa reticosa*." This shell is extremely abundant in the Red Crag, and less so in the Coralline, but, in East Anglia, it does not appear to have survived the close of the Red Crag period.

In the Manx Drift it is very abundant, and is associated with *Columbella sulcata*, and *Nassa monensis*, Red Crag species, and *Fusus Forbesii*, a large and handsome species, which is not known elsewhere either recent or fossil. A *Mitra* also occurs, which is either extinct or a southern species. In the Wexford Drift *N. reticosa* is found, together with *Melampus pyramidalis* (otherwise confined to the Pliocenes of East Anglia and Cornwall), a *Mitra*, and *Turritella triplicata*, Broc. (=*T. incrassata*, Sow.), a species very abundant in British seas in the early part of the Pliocene period, but now banished to the Mediterranean. Other shells of equal interest could be added, but space forbids.

How shall we interpret these facts? Are they best explained by supposing the shells to have inhabited a sea which had, albeit over 200 fathoms deep, no deep-water fauna at all, which nowhere left a shell-bank or even a group of shells on the spot where they lived (on this point Gwyn Jeffreys and Mr. R. D. Darbishire spoke very explicitly), which mingled shells of the most diverse habitat and left shells at present confined to shallow water and a sandy bottom in the muds of its profoundest depths, a sea which pertinaciously avoided the deep gulfs between the tiny islets that studded its surface, and that finally retired without leaving beach, shore-platform, or so much as a cliff or sea-worn cave behind to mark its former extension.

Or, do not the facts harmonize better with the view, so strongly supported by the physical indications, that the ice-sheet, whose extension over the district and in the direction I postulate is admitted by Mr. Reade,[1] having advanced over the Irish Sea, bore along involved in its mass or in its ground-moraine portions of the vast banks of shells with which that, then as now, *shallow* sea was cumbered, and mixed up the mangled remains, not only of the but-recently-vacated boreal forms, but also of the warm-water species which lived in the preceding Pliocene Period.

In conclusion I would remark that it is before all things necessary, in the discussion of the question of the condition of Britain during the Glacial Period, to take a pretty wide survey of the country, and to try and bring all the facts into a single *coup d'œil.* The former Mr. Reade has certainly done, as witness his papers on the Drift of Cromer and Yorkshire; but the latter I fear he has not attempted, else we should hear less of the significance of the fact that Three Rock Mountain, Moel Tryfaen, Gloppa, and Macclesfield are at about the same altitude and on the same parallel of latitude. Let Mr. Reade look 20 or 30 miles E. and W. of his terminals and see in what way his great submergence declined.

I have touched but upon the fringe of a great subject, and must leave the publication of a more general statement of my views till the autumn, when Prof. G. F. Wright's new volume in the International Scientific Series, to which I have contributed a chapter, will be out. In the meantime Mr. Reade will, I hope, deal with some of the topics which I suggested at the outset.

VI.—SELENOLOGY.

By S. E. PEAL, Esq.

AS one who has for many years made a special study of the lunar surface, and who is thoroughly convinced that the geologist alone can now extricate selenology from the slough in which it has hopelessly stuck fast, I venture very briefly to lay the case before your readers, in the hope that some one will come forward and help us.

---

[1] See his papers in the Q.J.G.S., and "Nature," vol. xl. p. 247.

As regards its distance, motions, and topography, or mapping of the surface details, our knowledge of the moon is well to the fore, every little mound and fault being carefully recorded; but what the surface, so clearly seen, is composed of—whether of volcanic or stratified rocks, or otherwise—no one can say.

The structure and material of the surface is in fact a most hopeless enigma, and this is all the more extraordinary when we recollect that of all the heavenly host, our moon is the nearest body, and that most frequently and easily seen, being totally unobscured by atmosphere or clouds, and easily observed with small telescopes and low powers.

To some extent this want of progress in selenology is due to the old idea that the surface is now covered from pole to pole with the remains of lava-lakes and stupendous volcanic explosions, a vast cinder heap in fact, and is also partly due to the researches of Lord Rosse, which (erroneously as we now know) were held to demonstrate a maximum temperature of + 300° C. after 14 days' sunshine.

But our want of progress is also undoubtedly due in part to the general belief among astronomers, that a planet like our moon could actually pass from the semi-incandescent and lava-crusted stage, with huge vaporous envelope, direct to the cold, airless and waterless stage, without an era of erosion intervening.

Could retain, that is, its primeval volcanic surfacing throughout the long era succeeding, while the temperature slowly declined, and without the intervention of an era of erosion and deposition of sedimentary rocks, as on our Earth.

Judging by our own vast series of stratified rocks, we are led to conclude that an exceedingly long temperate 'era of erosion' must, in the very nature of things, supervene on the heated lava-lake stage, in all planetary development.

It is over this part of the question that I invoke the aid of your readers, *i.e.* to say, as geologists, whether they believe that a planet, such as our moon, could retain from the igneous-molten era, to its present *intensely* cold, airless and waterless condition, its pristine surfacing, the very poles themselves being covered (it is urged) with large and small volcanoes, untouched by the hand of time.

The experts who have specially studied the question, agree that the maximum surface temperature under 14 days' solar heat, is at or about zero, C.; and the minimum during the lunar night falls to about − 200° C.; the mean being so low that solar heat raises no trace of vapour, about the equator, at the limb.

Thus the surface temperature of the moon must have fallen enormously, and taken millions of years to do so.

To aid your geological readers who may not be aware of the peculiarities of the case I would point out that—

1. The moon (unlike Mars) has no polar caps.
2. There is an absence of all *distinct* colour in masses or in detail. Over the entire surface we find warm greys and neutral tints prevailing.
3. There is a general and conspicuous absence of all evidence of

drainage, and river valleys. The surface of the planet is literally covered with unearthly circular formations, from 10 to 100 or even 150 miles in diameter, enclosing level plains sunk from 1000 to 10,000 feet beneath the outer surface, and bordered by vast ramparts, having about the same cubic measurement as that of the excavation.

4. The mountains, peaks, and cliffs are white, and *whitest* where they are *steepest*. The darker parts of the surface are levels, as though due to accumulation of meteoric dust thereon.

5. There is an entire absence of *raised* level floors like those in terrestrial volcanoes, and there is no perceptible difference whatever between the polar and equatorial surfacing; if the large and small circular formations about the equator have been volcanoes, then have the lunar poles been finally surfaced in the same way.

Lastly, if, as is now generally admitted, the moon formerly rotated more rapidly on her axis, and has been slowed down by tidal friction, this would imply a temperate era, the existence of water, and of erosive action, which would have effectually scoured off all the so-called "volcanic" details now visible everywhere.

So far our moon, though so admirably suited in some ways for study by geologists, seems to have received rather scant attention. Professor Judd, in his most instructive work on Volcanoes, p. 305, says "the moon appears to be destitute of both atmosphere and water. Under these circumstances we find its surface, as we might expect, to be composed of rocks which appear to be entirely of igneous origin; the mountain-masses, unworn by rain or frost, river or glacier, being of most prodigious dimensions as compared with those of our own globe, while no feature at all resembling valleys, or plains, or alluvial flats are anywhere to be discerned upon the lunar surface."

The whole of Prof. Judd's work, however, is such a clear and beautiful demonstration, that without water there can be no volcano, that I feel sure he will excuse my pointing out the above difficulty.

With your permission I would like to say that if any reader desires to study my "Theory of Lunar Surfacing by Glaciation," it is to be had at Messrs. Thacker & Co.'s, 87, Newgate Street. I earnestly hope that some of your geological experts will take this matter in hand; it will certainly repay them, and perhaps enable selenology to make some advance, after prolonged stagnation.

SIBSAGAR, ASSAM, 11th June, 1892.

VII.—THE MAMMOTH AND THE GLACIAL DRIFT. A REPLY TO MR. A. J. JUKES-BROWNE.

By Sir HENRY H. HOWORTH, K.C.S.I., M.P., F.G.S., etc.

IN a letter in the last Number of the GEOLOGICAL MAGAZINE, Mr. Jukes-Browne takes me to task, with some asperity of language, for my views on the true horizon of the Mammoth, You will, I am sure, allow me to reply to him. He speaks of my "looking down from some literary height upon practical geologists in the plain," and goes on to say that I have "no practical experience as a geologist, and bids me study the facts in the field."

This is certainly a sublime height from which I never addressed anybody. The language compels me to say, much to my distaste, that for many years past I have spent my holidays in trying to explore the so-called Glacial beds in Scotland, Eastern and Western England, Holland, North Germany, Denmark, the Scandinavian Peninsula, Finland, and Switzerland. It is possible, but it is not probable, that Mr. Jukes-Browne has studied them *in the field* in as many aspects and for as many years as I have.

Two lessons, *inter alia*, this examination has taught me, namely, the extreme difficulty of disentangling the history of these beds, and the impossibility of any individual explorer doing so unless, and until, he has mastered not only the facts in the field, which are comparatively easy to collect, but the vast and intricate literature dealing with the subject. I am not alone in this view. It is now some years since I paid my first visit to the Cromer Cliffs with two distinguished geological friends who knew them well. When we had finished our examination, and had concluded, as many others have concluded before, that the riddles they enshrine are not solved by any current theory about them, one of my friends, a geological surveyor, went on to say that what we needed far more than a continual accession of disintegrated facts, where facts are so abundant, was a sifting of the enormous literature relating to the so-called Glacial beds, so that we might marshal the testimony of the hundreds of observers and get rid of the personal equation which underlies them. I thought this a sensible remark, and I have probably devoted as much time to the very dreary work as anybody. One result will appear in the course of a few weeks in a work of 900 closely packed pages on what I have ventured to call the Glacial Nightmare. Another result I have tried to present in the pages of the GEOLOGICAL MAGAZINE. Mr. Jukes-Browne affects to despise this kind of work, and yet I have no doubt he agrees with me that any man deserves condemnation who in these days, when so many busy hands and eyes are at work, ventures to publish as his own what others have published long before and consequently that no one has a right to publish a fact until he has taken great pains to find out that it is new and of some importance, as well as true.

What I have done, and shall continue to do, in any geological excursions I may make, is, not only to report my own limited experience in the field, but also to bring together, as far as my bad health and mortgaged time will allow, the varying and contradictory testimony of other explorers, many of them better men than myself, and to try and equate their testimony with some positive conclusion. In many cases it is impossible to re-examine the sections, since they are effaced, and if they were not, my own observations would not, in my eyes, be of greater authority than those testified to by others, whose judgment I respect. We all need checking, and all our testimony needs sifting, and nowhere more so than when stupendous issues depend upon the result.

I hold it to be of very great importance, not merely on the question of settling the succession of the surface beds, but in tracing the beginnings of human life on the earth, that we should if we can, fix the horizon of the Mammoth beds. I have therefore applied what I hope is candid criticism to the evidence in regard to them, and the result is a conviction in my own mind that the evidence breaks down or is most unsatisfactory in every case which is supposed to prove that the Mammoth lived *after* the distribution of the drifts. Mr. Jukes-Browne says that I claim to have proved a universal negative, which is beyond human power. My object was very much more modest. It was merely to conclude from the *available*, not the *unavailable*, evidence that the case for the existence of the Mammoth after the distribution of the Drifts entirely breaks down. My conclusion was certainly not the result of *à priori* prejudice, for I have openly recanted some of my early views on this very subject, drawn from a partial and imperfect induction. That any one should be deemed guilty of anything but a service to science who subjects the discordant and divergent testimonies of "practical geologists" to criticism, is a curious instance of a reversion to ecclesiastical methods of discussion.

Mr. Jukes-Browne does not profess to meet my arguments or deny my conclusions, except in one instance, namely, that of Burgh, in Lincolnshire. This is a peculiarly unfortunate instance, because whatever views may have been held about the Mammoth having been an inter-glacial animal, I do not know any one who contends that the *E. antiquus* and the *R. leptorhinus*, both of which were found in the bed in question at Burgh, and both of which belong to an older horizon, can have lived during some interval in the so-called glacial age. Mr. Jukes-Browne's test of my capacity, namely, that I have mistaken one part of the valley of the Ouse for another, is, as your readers can see if they will turn to what I wrote, a test only of my critic's knowledge of the English language. I have nothing to correct, and nothing to alter in what I wrote, save the spelling of the word *remanié*, which was due to the printer's difficulty with my writing; but I emphatically re-assert my very strong objection to the basing of such a tremendous postulate as the intercalation of a Mammoth period between two ice ages, upon the broken down and utterly fragile evidence which is alone forthcoming to support it.

Lastly, Mr. Jukes-Browne, who apparently fancies that I am a wealthy man, instead of being a very poor one, bids me dig and test the case in a proper way, like my friend General Pitt-Rivers has tested other questions. I wish I could afford to dig. for I quite agree with him about the absolute necessity of digging, if we are to test the case properly; and I have said so very strongly at the two last anniversary dinners of the Geological Society. Nothing to me seems more futile and absurd than that a great public institution like the Geological Survey, should devote years of the work of some of the ablest men it can command, including Mr. Jukes-Browne, and expect them to report upon the most difficult beds in the world, and to do so and to map with no other evidence before them than the sections in casual clay-pits or chalk-pits, or in the sea-cliffs; sections which have been read almost in as many ways as there have been explorers. No wonder that the results satisfy nobody, least of all (as I know in several cases) the reporters themselves. All this I quite agree in, and I hope if the Government will not find money, the British Association or the Royal Society will do so, in order that we may have some test digging. What I do object to is that Mr. Jukes-Browne should transfer the burden of proof to my shoulders, and that he should bid *me* dig, in order to supply the lack of evidence for *his* conclusions. The burden of my paper is to show that the case of those who affirm the so-called inter-glacial or post-glacial existence of the Mammoth completely breaks down when tested. It is, therefore, for the champions of that view to find some evidence to support it which is not entirely fly-blown. Those who ought to dig are those whose case is in jeopardy. No one would welcome such digging more than myself, whatever its results, for I never can understand the pique and temper which some men show when their views are no longer tenable, as if all human knowledge were not more or less tentative; and as if any sensible man values an hypothesis by its finality. Let Mr. Jukes-Browne, then, press on, with the help of us all, in the application of a real test to the evidence in question; and if we cannot have digging, let us at all events retain our scientific credit by applying adequate criticism to every statement and every fact upon which a wide-reaching conclusion is based.

NOTICES OF MEMOIRS.

I.—On a Sample of Cone-in-Cone Structure, found at Picton, New South Wales.[1] By A. J. Sach, F.C.S.

The so-called Cone-in-Cone structure, which appears to be found in most countries, and which consists either of impure carbonate of lime or, less frequently, of impure carbonate of iron, still awaits a satisfactory explanation as to its mode of formation. It is more for the sake of eliciting the opinions of the geologists now assembled, than of advancing any theory of my own, that I exhibit the present specimen, and offer a few remarks on its composition and structure.

Out of some half-dozen of geological text-books that I consulted in the public libraries of Sydney, that by Sir Archibald Geikie, F.R.S., is the only one containing a reference to the Cone-in-Cone structure. Geikie appears to adopt the opinion of Professor Marsh, who states that the complex structure known as Cone-in-Cone may be due to the action of pressure upon concretions in the course of formation.

H. C. Sorby, F.R.S., in a paper read before the British Association, 1859, stated that he had examined transparent sections of the structure with a low magnifying power under polarized light, and concluded that it was intimately connected with some kind of Oolitic grains, which have crystals of calcium carbonate deposited almost entirely on one side along the axis of the cones in such a fan-shaped manner as to give rise to their conical shape. He states his conviction that the structure is one of the peculiar form of concretions formed after the deposition of the rock in which they occur by the crystallization of the calcium carbonate and other isomorphous bases.

---

[1] Read before the Australian Association for the Advancement of Science, Section C. (Geology); Hobart, 1892.

Dr. Dawson, in his Acadian Geology, 1868, asserts that the structure is produced by concretionary action proceeding from the surface of a bed or layer, and modified by gradual compression of the material.

R. Daintree, F.G.S., Quarterly Journal of Geological Society, vol. xxviii. 1872, says that the structure has more of the appearance of a chemical precipitate than of a mechanical deposit.

John Young, F.G.S., Transactions of the Geological Society of Glasgow, vol. viii., read a paper on the subject in 1885. He possessed evidence that the band of Cone-in-Cone structure, which he described, rested on a clay-band ironstone, and that it was on the same horizon as a bed of stratified shale, composed in bulk of calcareous shells of Entomostraca, of species frequenting lacustrine waters. He possessed many samples of the mineral which had been found in Scotland, and none had been associated with marine deposits. After careful examination he concluded that the Cone-in-Cone structure is the result of a mechanical action set up by chemical agencies generated in the stratum, and whilst the deposition of the sediment was going on. The chemical agencies were the outward and upward escape of gases generated by the decomposition of organic matter in the deposit; the gases, as they escaped through the oozy and plastic mud, elevated the sediment around the several points of eruption into ring-like layers.

The sample which I now exhibit occurs at Picton, New South Wales, in the upper course of the Picton Creek, which traverses a valley locally known as Glenforsa. The hills on either side are well-grassed slopes of Wianamatta shales, which are of Triassic age, and are generally considered of fresh-water origin. I do not know of any extensive shell-beds or other lime deposit found in the shales, but when traversing the glen some irregular nodules of calcium carbonate were picked out of the banks of the creek. The Cone-in-Cone mineral occurs as a horizontal layer, which is exposed in the bed of the creek, but passes under the adjoining bank. So far as I could learn, it is not now in process of formation. The thickness is about two inches, composed entirely of cones within cones closely packed together. It has been asserted that in some European specimens the apices of the cones point both upward and downward, but in the specimen now under consideration all the apices point downward. The open bases of the cones, formed of ampitheatre-like cavities, are about half an inch in diameter, and small ones are sometimes formed within the larger ones. The chemical composition of the specimen is, approximately—Calcium carbonate, 67·54 per cent.; matter insoluble in strong hydrochloric acid, 21·2; sesquioxide of iron, 4·14; magnesium carbonate, 0·7; water, 3·1. In some parts the mineral is distinctly crystalline, and, in my opinion, a purely mechanical origin can scarcely be entertained. It appears to be a chemical precipitate which has resulted in imperfect or disguised crystallization. The floor crystallizations, known as "crystal cities," at the Jenolan Caves, N.S.W., have a somewhat similar external form. The mineral might have been formed in the drying up of the calcareous waters of a lake.

PAPERS AND REPORTS READ BEFORE THE BRITISH ASSOCIATION, EDINBURGH, AUGUST, 1892.

II.—REPORT OF THE COMMITTEE, consisting of Messrs. H. BAUERMAN, F. W. RUDLER, and J. J. H. TEALL, and Dr. JOHNSTON-LAVIS, appointed for the investigation of the Volcanic Phenomena of Vesuvius and its Neighbourhood. (Drawn up by Dr. JOHNSTON-LAVIS.)

SINCE the last Report, nearly all the tunnelling for the great main sewer is complete, and few additional facts of interest have come to light. Several little problems of purely local geology have, however, been solved. In the lower sewer collector, beneath the tramway tunnel of Naples, a peculiar grey trachytic mass has been met with, and was penetrated for a short distance. On account of a lawsuit the works do not progress. The mass, however, is of considerable interest, as it is below the great yellow tuff of Posillipo and Naples. The rock was ejected rapidly in very pasty or almost solid fragments, which in some cases blended with the others thrown out just before and after, and are flattened out in a pipernoid manner. At other points the fragments are broken, mixed with dust, and consequently incoherent. When this deposit is cut through, it will probably confirm my theory regarding the piperno of Pianura and Soccavo, as being the result of lumps of lava ejected in great blobs, which, falling quite hot around the vent, have become resoldered together, and have even flowed a little.

Very high temperatures have been met with in the tunnel near the Solfatara, where I registered myself 59° C. on a day that the workmen considered a very fresh one for the workings, *i.e.*, with a high barometer still rising.

The statement made many years since by Professor A. Scacchi, that fragments of leucitic lavas had been found by him at the Foce di Fusaro, near the Torre Gavetta, led me to suspect the existence there of the Museum breccia. On examining the locality this was confirmed, and, in fact, the whole sea cliff of Mte. di Procida exhibits a most interesting, though complex, section of the volcanic series of the Phlegrean Fields.

We there have a series of trachytes forming the base of the section, very various in texture, and often covered with thick beds of their own scoriæ, which are often consolidated into a kind of trachytic breccia quite analogous to the 'sperrone' of the Alban hills. This is overlaid by fine lapilli and pumice beds, which vary very much in thickness. Lying unconformably upon these are irregular buried outliers of the grey pipernoid tuff of the region.

In one place the pipernoid tuff is seen in section as an exceedingly obtuse V-shaped mass, having choked an old valley, and possessing the following characters: The black scoria fragments are very slightly, if at all, flattened, are very spongy, are of good size, and form an important constituent of the deposit. From this we can conclude that the distance would well correspond with my supposed eruptive mouth to the S.S.W. of Camaldoli, not very far from the Lago d'Agnano, from which I believed issued the piperno and the greater part of the pipernoid tuff of the Campania. The distance was, in fact, such as to allow time for only the lighter pieces of scoriæ, the equivalent to the black flackers of the piperno, to travel so far, and these to be so cooled, that when they fell they were sufficiently rigid to no longer be flattened out by the impact.

This grey pipernoid tuff has here suffered much denudation, for in many places it is quite removed. Towards Torre Gavetta the 'Museum' breccia is well developed, being composed of very large blocks of the numerous varied rocks, followed by beds of the woody pumice, woody looking scoriæ, and scoriaceous black centred vitreous trachyte fragments and pumice. Lying with very marked unconformability upon it is a great thick bed of the compact yellow tuff, either derived from Campagnone or the neighbouring cone, a slice of which forms Misenum. In this section we have splendidly exhibited many of the great geological records in the history of this remarkable volcanic region. Each of these stages is defined from those above and below it by more or less long periods, during which, in some cases, very extensive denudation had taken place. At this point also I am satisfied we have products of the eruptions of the Procida and neighbouring centres interstratified with those of the mainland, and in which in time I hope to work out the relative chronology.

The discoveries, which in so striking a manner confirm my conclusions regarding the highly complex stratigraphy of this region, induced me once more to examine in detail that isolated eminence upon which once stood the renowned Greek town of Cumæ, founded about 1000 B.C.

Time has favoured the geologist, for here, however much the archæologist may grieve, it has once more exposed to human eyes sections that for many centuries were hidden by buildings, but which reveal the fact that those very rocks that, as geologists, we look upon as very recent, had nearly 3000 years since much the same characters as now. The pumices that form the uppermost yellow tuff had then already been converted into a rock that those early colonists cut out and used for the construction of their walls. When we first visit Cumæ, and our thoughts wander back through historic time, we are impressed by the human associations with this hill for such a long period; but when we return with our eyes and minds geologically cultured, the ancient Greek town sinks into insignificance by the side of the physical history of the mound it stood upon, when we remember that not only this mound, but the whole region is post-Pliocene in age.

The foundation of the Cumean hill is the well-known trachyte, rich in inclusions of sodalite, of amphibole, and I have detected, not uncommonly, crystals of fayalite. Were it more vesicular it would very much resemble the western mass of trachyte of the Cumana railway tunnel at the back of Naples.

Above this come some pumice and dust beds, which are probably the equivalent of the Rione Amedeo tuffs. Superposed on this we find a dirty grey pipernoid tuff which shows much *remaniement*. The Museum breccia is well represented in patches, and is overlaid by a bed of vitreous trachyte produced by the resoldering of the falling masses into one solid stratum, where the surface was flat, but where on an incline the fragments have remained separate. The whole is capped by the compact yellow tuff. There are also some minor pumice and dust beds which require further working out.

The trachyte seems to have oozed forth in a highly pasty condition, breaking up its scoriaceous surface, which rolled down the sides of the dome-shaped mass, and by pressure and heat from the main mass become again soldered together—in fact, a sort of regelation. The brecciated structure is undiscernible in hand specimens or under the microscope, but is well etched out by meteoric agencies. Each of the deposits mentioned above shows more or less unconformability, which correspond as they themselves do with those beds of the Monte Santo Funicular Railway, the Cumana Railway, Pianura, Soccavo, Monte di Procida, Nocera, Castellamare, St. Agata, Capri, Caserta, etc., that I have described in other reports and papers.

These are the principal sections which record the later geological history of the Phlegrean Fields, and from which I have been able to unravel the stratigraphy of the highly complex Neapolitan volcanic region. So far it has been explained only in these reports and other disjointed papers, but before long I hope to be able to place before the scientific world a far more detailed description of one of the most interesting as well as the most classic and accessible volcanic regions of the world.

Before quitting the subject, however, I wish to call attention to the confirmation that the sections mentioned in this Report afford of my explanation of the piperno and pipernoid structure in general. We see distinctly that the variation in colour and texture of the two constituents of the piperno, which chemically are identical, is simply due to the greater saturation with H_2O of one portion of the magma than the other in the old chimney of the volcano at the time of the eruption. The consequence was that the more aquiferous part was erupted as a fine dust, and the less aquiferous, more coherent magma was ejected in large fragments or more or less scoriaceous cakes, which lost their heat the more slowly, in proportion to the less water they contained. The densest, and at the same time the slowest to cool, fell near the eruptive mouth, flattened out, squeezed out those beneath them, and were squeezed out by those above them, forming, with the included dust, the compact piperno in which the foliated structure is most developed towards the west end of the

Soccavo section, where the nearest existing remnant to the old crater is now preserved, and where the inclination was greatest, and consequently where actually slight flow took place. The more scoriaceous of these lava cakes were carried to greater distances, so that as we travel away from the eruptive axis we find, first, that the black fragments become less markedly flattened because they cooled more rapidly from expansion, and also because they travelled farther, until they no longer show flattening parallel to the bedding more than what would be due to any of them being accidentally of a flattened or elongated form, and so lying flat on the surface they fell upon; second, we find that as their radial distance from the eruptive axis increased, the fragments at first get lighter; and third, when the limit of lightness and cohesion is reached, they get smaller and smaller, so that at Roccamonfina and Salerno the pipernoid tuff is chiefly composed of the grey dust with only few and minute fragments of black scoriæ. This seems to have been modified by strong winds and possibly by the eruption taking place along a cleft much like that formed in the late Tarawera eruption, or as in many cases in Iceland, such as the Skaptar outburst, though most of the latter locality does not belong to explosive types of eruptions.

There is in Iceland, at Krisuvik, the principal one of several crater lakes that exhibit in a striking manner the resoldering together of ejected fragments, into what might at first appear to be a true lava stream. I allude to the Groenavatn, in which we have an almost circular conical hollow nearly filled with water. There is only a very low ring round it, composed of *accidental* ejectamenta, being nothing more than the ejected fragments of the materials, through which it was drilled, with practically no essential ejecta, except on one side, where we have a mass of rock that looks like a lava stream. It seems there must have been at the moment of the eruption a very strong wind which carried all the lava fragments in one direction, and as they fell they blended together into one fairly uniform mass, the components of which are only faintly indicated by a slight variation in colour, somewhat like piperno, but not so well marked. The top and bottom are less coherent, for at the bottom the fragments fell on cold ground, whilst the top, although falling on the hot mass beneath, could not be pressed into contact with it by later falls. No doubt also the explosions were feebler towards the end and the interval longer between the fall of the last fragments.

We find exactly the same thing in the piperno, namely, a spongy tufaceous-like bottom and top. Besides this, the lulls and accentuations of the explosive action are well marked, as well as the time that large masses of the crater edges fell in and were re-ejected. At one time the eruptive action seems to have been arrested, and the partly or entirely consolidated plug was blown out into fragments and deposited amongst the piperno.

Vesuvius has since the last report, up to the time of my last visit [illegible] May, shown very little variation. It will be remembered that [illegible] was issuing at the site of the eruption of June 7, 1891, at the foot of the great cone, more than three hundred metres below the summit at the junction with the Atrio del Cavallo, and nearly opposite the Punta del Nasone. This outpour practically never stopped—at times it increased to no inconsiderable quantities, but flowed only a short distance, on account of the low gradient, tending to pile itself up into a mound. On other occasions it seemed to become almost arrested, but it never practically stopped. The consequence of all this was that at the foot of the great cone in the Atrio, during the year from June 1891 to June 1892, a tremendous mound or low-pitched buttress had been built up, so that its highest part I estimate to be 20 m. above the old floor of the Atrio. This thickening away in all directions, but even under the escarpment of Somma, the present floor stands for considerable distances over 5 m. higher. In consequence of this many of the dyke numbers which cost me so much labour to put up some years since have been covered over. These I hope to be able to replace this winter, and to repaint all the rest that are now becoming obliterated. It will be remembered that these numbers correspond with the dykes figured in my geological map of Vesuvius, and all collectors now adopt these numbers to indicate the locality of the dyke from which the specimens were obtained. Professor Bassani has added a new and complete collection of these interesting dyke rocks to the Naples Museum, and has arranged them according to my numbering. The great importance will be seen of maintaining this numbering intact.

The actual details of the variations in the activity are as follows. During the summer and autumn of 1891 more crumbling in of the crater edges took place, followed by black sand and dust-charged vapour. The outpour of lava from the base of the cone in the Atrio from time to time almost stopped, to be followed again by fresh gushes. On the first day of December a marked extension took place to the south and south-east of the crater by the further crumbling in of its edges. On the last day of the old year and commencement of 1892, the outflow was much accentuated. During January and February few variations were observable, but on March 17 and 18 slight reflection from the crater was visible for the first time for nearly a year, showing the rise of the lava in the chimney, due certainly in part from blocking of the lateral channel as the outflow of lava below was markedly diminished. On the 21st the activity at the crater was distinctly at the first degree, but on the 22nd the second degree was attained. On that evening, however, a gush of lava showed the removal of the lateral obstruction to its outflow, and the central activity so diminished that the following night no reflection was visible. On March 29 and 31 the crater again showed the first degree of activity.

This was followed during the first week of April by a fresh outflow of lava, which still more increased during the next week. During the first four days of the month feeble reflection was from time to time visible from the crater. On the 12th, black dusty smoke was puffed out from time to time. On visiting the Atrio, I found the lava that flowed had formed the mound above spoken of, surmounted by the fumaroles figured.

During the night of May 3–4 fresh portions of the crater wall collapsed and blocked the vent, so that during the following day hardly any vapour crowned the summit of the volcano. By the next day the increased tension of the vapour was sufficient for it to force its way through the obstruction, and much black sandy smoke escaped during the 5th, 6th, 7th, and 8th. Obstructing masses that had detached themselves from the crater sides again plugged the vent on the 27th and 28th, followed the next day by dark, sandy, and dusty smoke.

The flowing lava showed few new phenomena, with the exception of the fine examples of conical and tubular spiracles formed above the lava exit at the same locality, but above one set figured in the last report that are now buried. One of these is unique on account of its curved overhanging form. It has been ejected at the highest point of the new lava, and quite at the foot of the great Vesuvian cone. I can only explain its inclination at the lower part, other than that the escape of vapour and lava fragment were projected upwards and outwards in a plane radial to the volcanic chimney which corresponds with the orientation of the fumarole. This lateral projection seems to have gone on for some time, so that many of the blobs of lava blown out, fell and formed a support for the inclined tube. As the blasts escaped more feebly the edges of the mouth became more solid, and so the lower lip diverted the column more in an upright direction, until the growth became almost vertical. The whole effect is to produce a large mass somewhat resembling a recumbent animal with its neck and head erect.

About twenty yards more distant from the foot of the cone was another large, obtuse, conical-shaped fumarole, which had been broken away on one side and well exhibited the dome-like interior covered by stalactitic lava. These constitute very fine examples of what kind of spiracles may be built up on the surface of a coarsely crystalline lava, such as that now issuing from Vesuvius. They differ very considerably from those described and illustrated by Dana and others from Hawaii, as also those formed on acid lavas at Reunion, of which one or two figures have been published.

At the time of visiting these fumaroles I was accompanied by my friend Dr. R. D. Roberts, of London, who was much interested in these striking formations. He is a man of average height, so that the dimensions of these fumaroles can be judged of by comparison with his figure by their side (photographs exhibited).

At the summit of the great cone few changes have occurred beyond the further enlargement of the crater. When slips took place from the edges, dark dust-laden vapour was puffed out from time to time. On one or two occasions the lava rose sufficiently high in the chimney, combined with the sufficiently strong explosions, to project a few lava cakes beyond the crater edges. The bottom of the crater has been invisible from the large amount of vapour present on each [illegible]sion that I visited the mountain summit. The extreme truncation of the old eruptive cone is very strikingly seen by comparing the photograph, taken a little over a year ago and published in the last report, and the present one (photographs exhibited).

Since I quitted Naples an actual crateret has opened in the Atrio at the point where these fumaroles stood, and several gushes of lava have taken place. I shall more fully report on these new phases on my return to Naples.

III.—Ninth Report of the Committee, consisting of Professor T. Wiltshire (Chairman), Dr. H. Woodward, and Professor T. Rupert Jones (Secretary), on the Fossil Phyllopoda of the Palæozoic Rocks. (Drawn up by Professor T. Rupert Jones.)[1]

EIGHT reports by this Committee have been handed in and printed, the last in 1890. Part I. of the 'Monograph on the British Fossil Phyllopoda,' by Prof. T. Rupert Jones and Dr. H. Woodward, published by the Palæontographical Society, contained twelve plates, illustrating thirty-nine species, belonging to four genera of *Phyllocarida* (*Ceratiocaridæ*) therein described. Part II. of that Monograph is now finished, and has five plates of twenty-eight species in seven genera (including some of both the bivalve and the univalve *Phyllocarida*).

The genera here treated of are *Hymenocaris*, *Lingulocaris*, *Saccocaris*, *Caryocaris*, *Aptychopsis*, *Peltocaris*, *Pinnocaris*, and *Discinocaris*.

I. Of *Hymenocaris* we know of only two species, both British, namely, (1) *H. vermicauda*, Salter, very common in some beds of the Lingula-flags in North Wales; and (2) *H. lata*, Salter, represented by a unique and distorted specimen from the same strata.

II. Of *Lingulocaris* there are (1) *L. lingulæcomes*, Salter; (2) *L. siliquiformis*, Jones; and (3) *L. Salteriana*, T. R. J. and H. W. These are from the Cambrian of North Wales.

III. *Saccocaris major*, Salter, from the Lingula-flags, and *S. minor*, T. R. J. and H. W., from the Arenig series, are described and figured.

IV. *Caryocaris Wrightii*, Salter, and the thinner *C. Marrii*, Hicks, from the Skiddaw slates of Westmoreland, are fully treated of; and it is suggested that the latter form is possibly due to a sexual difference.

V. Of *Aptychopsis* we have recognized thirteen species, mostly British: 1. *A. prima*, Barrande, with its varieties *longa* and *secunda*, all Bohemian. 2. *A. Barrandeana*, sp. nov., and its variety *brevior*, nov. 3. *A. cordiformis*, sp. nov. 4. *A. lata*, sp. nov. 5. *A. glabra*, H. W. 6. *A. Wilsoni*, H. W. 7. *A. Salteri*, H. W. 8. *A. Lapworthi*, H. W. 9. *A. ovata*, sp. nov. 10. *A. subquadrata*, sp. nov. 11. *A. angulata*, Baily. 12. *A. oblata*, sp. nov.

Nos. 5 and 8 are probably represented among the several figures of various forms of '*Aptychopsis prima*' given by Barrande in his Syst. Silur. Bohême, vol i., Supplement, 1872, plate xxxiii.

Nos. 10 and 11 are from the Silurian of Ireland; the others (excepting No. 7, from South Wales) are from the Moffat series of South Scotland.

---

[1] Read before (Section C) British Association, Edinburgh, August, 1892.

VI. Three species of *Peltocaris* are (1) *P. aptychoides*, Salter; (2) *P. anatina*, Salter; (3) *P. patula*, sp. nov.

Like *Aptychopsis*, *Peltocaris* is an Upper-Silurian British form, with some representatives in the Middle Silurian.

VII. *Pinnocaris Lapworthi*, Etheridge, jun., a rare Silurian form, is known in Ayrshire and Westmoreland.

VIII. Of the round subconical tests, undivided except by the triangular nuchal notch, *Discinocaris* gives four species, all from the Upper or Middle Silurian of South Scotland and Westmoreland: 1. *D. Browniana*, H. W. 2. *D. ovalis*, sp. nov. 3. *D. undulata*, sp. nov. 4. *D. gigas*, H. W.

The British specimens here referred to belong to—(1) the British Museum; (2) the Museum of Practical Geology and Geological Survey of Great Britain; (3) Museum of the Geological Survey of Scotland; (4) Museum of the Geological Survey of Ireland; (5) Woodwardian Museum, Cambridge; (6) Museum of the Owens College, Manchester. The authorities of these institutions have courteously given us facilities (by loan or otherwise) for studying the specimens. For the loan of a large series we owe thanks to Mr. J. D. Brown, of Moffat, and for others to Dr. C. Lapworth, of Birmingham. The late Mr. James Dairon, of Glasgow, also obligingly lent us some specimens.

The *Pinacaridæ* (*Dithyrocaris*, etc.) have next to be described and figured in detail; and further descriptions and figures are required of the *Ceratiocaridæ*, for which the Committee have accumulated much material. Mr. J. G. Williams, F.G.S., of Ffestiniog, has lent the Committee a large series of North-Welsh Phyllocarids, including *Hymenocaris* and other genera, which will require careful study.

The chief additions since 1889 to published information about the Palæozoic *Phyllopoda* are—

1. Some notes on the Devonian *Estheria membranacea*, with a figure and description of an oblong variety, showing the concentric riblets and interstitial ornament, in the GEOLOGICAL MAGAZINE, 1890, Pl. XII. Fig. 9, and 1891, p. 50.

2. In his Mémoire sur la Faune du Grès Armoricain (Annales Soc. Géol. du Nord, vol. xix. 1891), Dr. C. Barrois, after noting (pp. 147 and 149) that the little fossil, quoted by MM. de Tromelin and Lebesconte as *Cytheropsis subtestis* (Report Assoc. Franç. Congrès de Nantes, 1875 [1876], p. 23) is a *Primitia*, near *P. debilis*, Barrande, proceeds to treat of *Myocaris lutraria* at pp. 220 and 221, pl. v. fig. 4; and describes a small caudal spine, probably of a *Ceratiocaris*, p. 221, pl. v. fig. 3; also an abdominal segment and caudal appendages (style and stylets) of a new Ceratiocarid, namely, '*Trigonocarys*' [*Trigonocaris*] *Lebescontei*, nov. gen. et sp., pp. 222–226, pl. v. figs. 5 and 6; all from Guichen.

3. Description of Fossils from the Palæozoic Rocks of Ohio, by R. P. Whitfield (Annals New York Acad. Science, vol. v. December, 1890):—

Page 562. PHYLLOPODA, p. 563, *Echinocaris*, Whitfield (Amer. Journ. Sci. 1880).

At pp. 564–5, seven groups of *Ceratiocaridæ* are defined, according to their segments, etc.

Page 565. *Echinocaris sublevis*, Whitfield, 1880, pl. xii. figs. 12–14.

Page 567. *E. pustulosa*, Whitfield, 1880, pl. xii. fig. 13.

Page 568. *E. multinodosa*, Whitfield, 1880, pl. xii. fig. 16.

From the Erie shales of Ohio (=Portage and Chemung groups of New York State). See Amer. Journ. Science, third series, vol. xix. p. 36, etc., 1880.

At p. 572. *Aristozoe canadensis*, Whitfield, 1880, pl. xii. figs. 17 and 18, from the Trenton formation in the Ottawa basin of Canada. Locality unknown. Introduced for comparison.

See also Report British Association for 1885 [1886], p. 35.

4. The illustrated description of *Discinocaris Dusliana*, by Prof. O. Novák, in the Geological Magazine, 1892, p. 148. This is one of three specimens found by Herr Dusl in the strata of the "Colonie Haidinger," Bohemia, and referred to by Mr. J. E. Marr, F.G.S., in the Quart. Journ. Geol. Soc., vol. xxxvi. 1880, p. 617.

5. The fauna of the Lower Cambrian, or Olenellus Zone, by Charles D. Walcott (Tenth Annual Report of the U.S. Geological Survey, 1891 ?); *Protocaris Marshi*, Walcott, p. 629, pl. lxxxi. fig. 6 (Bull. U.S. Geol. Surv., No. 30, 1886, p. 148, pl. xv. fig. 1):—an obscure subquadrate test (?), with a many-segmented body and a furcate caudal appendage (see our Seventh Report for 1889 [1890], p. 64).

IV.—On some *Dicynodont* and other Reptilian Remains from the Elgin Sandstone. By E. T. Newton, F.G.S., F.Z.S.

At the Aberdeen meeting of the British Association, in 1885, Dr. Traquair called attention to the skull of a *Dicynodont* which had been discovered in the Elgin Sandstone of Cutties' Hillock (=New Spynie). Since that time several other specimens have been obtained from the same place, some of which are the property of the Elgin Museum, while others belong to the Geological Survey of the United Kingdom. These specimens are now being worked out by the author, and this communication is a preliminary note on the interesting results which have been obtained.

All the reptile remains obtained from Cutties' Hillock are in the condition of hollow casts, the bones themselves having been dissolved away; this, it will be remembered, was the case with some of the examples of *Stagonolepis* from the Elgin Sandstone, described by Prof. Huxley, and the method of taking casts from the hollow cavities, which was adopted in that case, has been found of great advantage in the present instance. The blocks when brought from the quarry were more or less split open, exposing portions of the specimens. In some cases these cavities were traced out and developed with the chisel, while in others they were farther split open, thus allowing casts to be taken. In many cases these casts had to be made in several parts and afterwards fitted together. The time and labour involved in this task have been repaid by the restoration of the skulls and parts of skeletons of several *Dicynodonts*, and one or two other equally remarkable forms of reptiles.

In most of these specimens, including that noticed by Dr. Traquair, the skulls are similar in form, although differing in minor details, and have a general resemblance to the South African *Dicynodon* and *Oudenodon*, some of them having small tusks in the maxiliary bones. With most of these skulls parts of the skeleton have been found. Two or three show the position of the vertebral column and ribs, but up to the present no definite centra have been traced; besides this there is evidence of scapula, clavicle, humerus, radius, and ulna, the humerus having the characteristic anomodont expansion of the two extremities. In two specimens the ilia are preserved. These forms appear to be distinct from *Dicynodon*, and probably represent at least two or three species.

Another skull presents most of the characters of *Ptychognathus*, but has a short muzzle and no teeth. The last, and by far the most remarkable skull of this series, is about six inches in length, and has the outer surface completely covered in by bony plates, the nostrils, eyes, and pineal fossa being the only aperatures. The chief feature of this skull is the extreme development of horns upon the face and cheeks, there being about thirty of these formidable defences varying from a fourth of an inch to nearly three inches in length, besides some smaller bosses. The dentition is pleurodont, and resembles very closely that of the living *Iguana*; the palate is lacertilian. but with the pterygoids united in front of the pterygoid vacuity. This skull reminds one very strongly of the living *Moloch* and *Phrynosoma*, but it probably finds its nearest ally in the *Pareiasaurus* from the south African Karoo Bed. The detailed description of these specimens is nearly completed, and will, it is hoped, be shortly published.

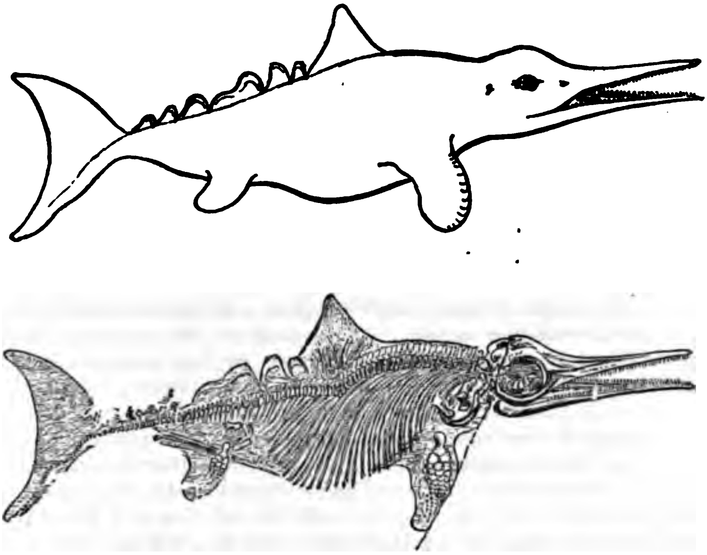
REVIEWS.

I.—THE PADDLES AND FINS OF ICHTHYOSAURUS.

UEBER EINEN NEUEN FUND von *Ichthyosaurus* IN WÜRTEMBERG. By DR. EVERHARD FRAAS. Neues Jahrb. 1892, vol. ii. pp. 87–90.

TRACES of the skin have long been known to occur with the remains of the skeleton of *Ichthyosaurus* in the fine-grained limestones and indurated shales of the Lias; and the descriptions of the integument of the paddle by Sir Richard Owen, Dr. Everhard Fraas, and Mr. Lydekker, are now familiar to most students. Hitherto, however, well-preserved specimens showing the precise contour of the animal, have been a desideratum; and we therefore note with especial pleasure the recent discovery by Dr. Everhard Fraas of an *Ichthyosaurus* with the nearly complete integument in the Upper Lias of Würtemberg. Through the courtesy of Dr. Fraas we are enabled to reproduce his drawing of the fossil, accompanied by an outline-restoration based upon the facts it makes known.

Zoologists commonly regard the Ichthyosaurian modification among reptiles as equivalent to that of the cetacea among mammals; and it is very interesting to find how remarkably dolphin-like is the restoration of *Ichthyosaurus* given by Dr. Fraas. There is a triangular dorsal fin, and also a large caudal fin; while a row of horny excrescences extends along the back from the former to the latter. *Ichthyosaurus*, however, differs essentially from the dolphins in having the great caudal fin vertically, instead of horizontally, extended. The vertebral column is continued to the point of one lobe, as in a heterocercal fish; but Dr. Fraas supposes that this was not the upper lobe (as in fishes), appearances suggesting rather that it was the lower lobe. In proportion to the size of the animal this fin is very large, and Dr. Fraas' discovery is an interesting confirmation of the surmise of Sir Richard Owen, who, many years ago, noticed the frequent dislocation of the tail of *Ichthyosaurus* at a fixed point, and could only explain the circumstance as due to the weight of a caudal fin dragging upon this part of the body after death.



Skeleton of *Ichthyosaurus* exhibiting the contour of the integument, with an outline-restoration of the same.

As yet the specimen described by Dr. Fraas is unique, and some points in his interpretation of the fossil may perhaps admit of more than one view. We can only hope that further evidence will soon be forthcoming, and meanwhile express our appreciation of the enthusiasm and success with which Dr. Fraas is prosecuting his researches among the Fossil Reptiles of Southern Germany.

II.—UNTERSUCHUNGEN UEBER DIE ORGANISATION UND SYSTEMATISCHE STELLUNG DER RECEPTACULITIDEN. VON HERMANN RAUFF. Abhandl. der k. bayer. Akademie der Wiss. II. cl., XVII. Bd., III. Abth. pp. 647–722, Pls. I.–VII.

RESEARCHES INTO THE ORGANIZATION AND SYSTEMATIC POSITION OF THE RECEPTACULITIDÆ. By HERMANN RAUFF.

AS part of a work on the fossil Sponges of Germany, Dr. Rauff has critically examined the Palæozoic fossils included in the family of the Receptaculitidæ, and in this Memoir he has given a more detailed description, with fuller illustrations of their structure, than has previously been attempted. The main characters of these fossils have long been known through the works of Billings, Gümbel, and other writers, but nevertheless some new and interesting points, well deserving of consideration, are here brought forward.

It is well known to palæontologists that the nature and relationship of *Receptaculites* and its allied genera have been fruitful subjects of discussion, and that they have at different times been placed in various divisions of the plant and animal kingdoms. In 1884, Hinde supported the view that they were sponges allied to the siliceous hexactinellidæ, on the ground that the individual elements or spicules—Meromen, as they are styled by Dr. Rauff—of which their walls are composed, very strongly resembled in general features, the spicules of recent and fossil hexactinellid sponges, and that, like these latter, they must have originally been composed of silica. In their present condition many of these fossils are of granular crystalline calcite; some, perhaps the majority of the specimens known, are only casts, more or less replaced by iron peroxide or other substances, others are now siliceous, but the silica in these is partially crystalline, and therefore not original, and occasionally a rare specimen occurs which is found to be composed of a finely fibrous carbonate of lime. In this latter condition there are traces of concentric layers of growth, and of an internal tube or canal in the vertical rays or pillars of the spicules, and this fibrous structure was regarded by Gümbel as the original skeleton of the organism; a view upheld and defended by Rauff in this Memoir. If this view is correct, all analogy with siliceous hexactinellids at once falls to the ground. The fibrous calcite in these particular specimens was considered by Hinde to be merely a replacement after silica in the same way that granular calcite very often replaces the silica in other fossil sponges, but Dr. Rauff maintains that this is mineralogically impossible; that no traces of the original lines of growth could be preserved in spicules thus replaced; and consequently that *Receptaculites* is a calcareous organism.

The question of the original mineral nature of these fossils is by no means a simple one, and one would like to have clearer evidence whether the fibrous carbonate of lime could possibly have resulted from replacement, or whether it is primarily of organic origin, as Dr. Rauff, following Gümbel, asserts it to be. There can be no doubt, that the original mineral structure of *Receptaculites* and its allies must have been extremely liable to change, for in by far the greater number of specimens, as already mentioned, it has either been entirely removed or replaced by granular calcite, silica or other substances, in very much the same way as we find the originally siliceous skeletons of fossil sponges; whilst in only two or three specimens is the skeleton composed of this peculiarly arranged fibrous calcite, believed to be its original structure. A very striking exemplification of the difficulty of satisfactorily determining whether this fibrous carbonate of lime is original, or secondary, is afforded by the inability of Dr. Rauff to make out whether the fibrous structure now occurring in the axial portion of the horizontal or tangential arms of the spicules of *Receptaculites*, represents an originally solid portion of the arm, or is merely secondary infilling of a canal or cavity. These doubtful structures, spindles as they are termed, prove very durable, and remain when the walls bounding them have disappeared. Dr. Rauff is inclined to consider the spindles to have been originally solid, but if one might judge from silicified specimens they are probably secondary solid infillings of an original canal or cavity in the arms.

Dr. Rauff definitely accepts the calcareous nature of the *Receptaculitida* and concludes, in spite of the remarkable general resemblance of their spicules to those of siliceous *hexactinellids*, that they could have no relationship to sponges. At the same time he is unable to find in them any resemblance or relationship to any other group of fossil or recent organisms, and can therefore give no clue to their probable position, although he thinks that the question of their alliance to the calcareous Algæ, such as the *Siphoneæ verticillatæ*, put forward by Steinmann, Deecke, and others, deserves further consideration.

As regards the general structure of *Receptaculites* itself, Dr. Rauff adopts Billings' view that they were, when perfect, conical or subspherical in form like *Ischadites*, and consequently that the cup or platter-shaped examples, which are the only ones known up to the present, are incomplete. Theoretically there is much to favour this view, more particularly as in no specimen yet discovered are the margins of the open cups perfect, but on the other hand it is very peculiar that the supposed upper parts of the specimens should not have been met with ere now, considering that the basal cups are in some beds numerous and fairly well preserved. Similarly the author regards the cup-shaped forms from the Bohemian Silurian, placed by Hinde under *Acanthochonia* as merely incomplete specimens of *Ischadites*. A significant indication that open cup-shaped specimens of *Receptaculites*, rather than the assumed conical forms, were present on the sea-bottom is shown by the fact that in an example figured by the author (pl. iii. fig. 8) a Stromatopora has established itself on the inner or upper surface of the wall which must consequently have been open and uncovered at the time.

In well-preserved specimens of *Receptaculites Neptuni*, the inner ends or feet of the vertical rays or pillars are inflated, so that they come in contact with each other, and form an inner or upper wall to the cup. In *R. occidentalis*, from Canada, this inner wall has been shown by Billings and Hinde to be regularly perforated by canals which communicated with the spaces between the pillars; but Dr. Rauff asserts, without having seen the Canadian specimens, that the perforations are only secondary, and not original; and that the inner wall is not penetrated by canals. But as far as can be judged from the author's figures of the inner wall of *R. orbis* (pl. iii. figs. 10, 10*a*; figs. 3, 4, p. 675), similar perforations are presented in it as in the Canadian species, and in this latter they are too distinct and regular to be explained away as produced by fossilization.

The author shows that the meridional arms of the spicules in *Receptaculites*, and possibly throughout the group, follow a very regular arrangement, whereby the arm directed to the nucleus or commencement of growth (proximal, Hinde; distal, Rauff) is tilted obliquely towards the outer surface, whilst the opposite arm points obliquely towards the interior of the organism.

Dr. Rauff considers that when complete the summit or upper end of *Ischadites* was completely closed, in spite of the fact that in all the specimens yet known in which the upper portion is preserved, there is a small aperture which communicates with the inner cavity. This apertural fact is attributed to subsequent injury in fossilization, or to artificial enlargement, by those who have studied and figured the specimens; but it may be noted that the existence of this summit aperture seems never to have been questioned previously. In another point the author differs from previous observers who have shown that the pillars or vertical rays in good specimens of *Ischadites Kœnigii* gradually taper to a point, and do not form an inner wall; but as a fragment of a poorly preserved drift-specimen shows trumpet-shaped inflations, the author concludes that these were the original terminations in this species, and explains the spicules with pointed ends as arising from subsequent alteration; but this explanation will certainly not account for the tapering spicular rays in some of the Gotland examples of *T. Kœnigii*, which show every indication of being complete.

Dr. Rauff refers to *Leptopoterion*, Ulrich, as a new genus of this family, characterized by the nearly uniform diminutive size of the summit plates of the spicules. The form has not yet been figured, and the only species has been described as a sponge.

In a promised future Supplement the author intends to describe the various species, and it is then to be hoped that he will be able to definitely settle some of the doubtful structural points, and at the same time bring forward some positive conclusions as to the systematic position of this peculiar family.

Some fresh information respecting the structure of *Sphærospongia tessellata*, Phill. sp., based on specimens from the Devonian rocks on the shores of Lake Manitoba, is given in a recently issued part of vol. i. Contributions to Canadian Palæontology, p. 259, pl. xxxiii. The summit in this species is stated to be formed by the convergence of the prolonged distal rays of the upper spicules in each longi-

-tudinal row, and there are no indications that the hexagonal plates of the rest of the surface reached over the apical portion. If this determination is correct, there would be free communication with the exterior at the summit of the organism.

III.—FIELD NOTES FROM THE SHAN HILLS (UPPER BURMA). By FRITZ NOETLING, Ph.D. Record Geol. Surv. India, vol. xxiii. part ii. pp. 78, 79. Calcutta, May, 1890.

THIS records the interesting occurrence of Limestones curiously resembling the *Echinosphæriten-kalk* of the Baltic provinces and Sweden. The fossils collected are fragments of an *Orthoceras*, belonging to the group of the Regulares; Crinoid stems of two different types; and an *Echinosphæra* of very large size. The latter is said by the author to be a new species, and is named by him *E. Kingi*; since, however, no diagnosis, or even description, is given, we are unable to accept this species, and we trust that the learned Director of the Indian Survey will not in future permit his name to be thus taken in vain. If this *Echinosphæra* is really a new species, we fail to see how it bears out the author's contention that the red limestone of Upper Burmah is on "the exact horizon" of the Baltic *Echinosphæriten-kalk*, and that an arm of the sea in which that was deposited must have stretched right down to south-eastern Asia. The genus *Echinosphæra* is, for the rest, by no means confined to a single horizon in the Ordovician. F. A. B.

REPORTS AND PROCEEDINGS.

THE CHAPELHALL "SHELL-BED," NEAR AIRDRIE.[1] By DUGALD BELL, F.G.S.

THE Chapelhall Shell-bed, near Airdrie, had often been adduced as proving a submergence of at least 526 feet. Mr. Bell reminded the members of what he had shown on a previous occasion—that the "shelly gravel" on Moel Tryfaen in Wales could not be accepted as a proof of submergence, there being every evidence that it is not really in place, or as laid down by the sea. There was a great difference between a submergence of 1360 feet and one of 526 feet, and we might more readily believe in the latter than in the former; but he thought the more it was considered the more doubtful and inconclusive did even the smaller submergence, as depending on this Chapelhall instance, appear. He described the locality, and pointed out how little was really known of the "deposit" in question. It was reported by Mr. James Russell, a mining engineer then living in the locality, as having been found while digging a well near the summit of one of the high ridges of Boulder-clay that abound in the neighbourhood. It was described by him as a bed of "reddish brick clay" containing marine shells, intercalated in the "tile" or Boulder-clay, which had a great thickness both above and below it.

---

[1] Report of a paper read before the Geological Society of Glasgow.

Mr. Smith of Jordanhill, who recorded the discovery in a paper read to the Geological Society in 1850, visited the locality, but does not appear to have seen the brick or shelly clay—only the "superincumbent matter which was left lying at the mouth of the well," and which he pronounced to be "true Till." He got some shells, however, from Mr. Russell, which seems to have been all of one species, *Tellina calcarea*. From that day to this, though the place had been visited by many geologists, yet, the well being built up, no one is known to have seen or examined this "shelly deposit." Mr. Russell stated that it was about two feet deep in the thickest part, but "thinned away rapidly on every side," so as to allow the Upper and Lower Till to come together. This had been confirmed by a new well having been sunk within a few yards of the old one without finding any trace of the "shell-bed." In short, it seemed to be quite a limited strip or patch of shelly clay, imbedded in the Till or Boulder-clay. And this appeared to be a very narrow foundation for all that had been built upon the section, namely, a period of severe Arctic conditions and massive land-ice; then a milder period of deep submergence; then a re-elevation of the land, and Arctic conditions and massive land-ice once more.

Mr. Bell commented on the many improbabilities involved in this intervening "deep submergence," whether regarded as due to an actual subsidence and re-elevation of the crust of the earth, or to the mass and attraction of the ice raising the general level of the sea in the Northern hemisphere. The latter was by far the more probable hypothesis, but neither by calculation nor by comparison with the facts presented in Norway and North America did it warrant us in assuming a submergence in this country of anything like 526 feet. There was absolutely no corroborative evidence for such a submergence, but much that led directly against it. No shells had been found at a similar level in other parts of the Midland Valley, nor in the numerous side valleys, where they would be more likely to be preserved than on this exposed knoll in the centre. None have been found in the Upper Boulder-clay, which, if all this valley had been a sea-bottom before the "second glaciation," should contain abundance of at least shelly fragments. Further, this shelly clay was said to have been deposited during a "mild inter-Glacial period," which would most probably accompany such a submergence; but the only species of shells found in it indicated not mild, but extremely cold conditions, this *Tellina* being a characteristic Arctic species not now found living in the British seas. In short, he thought the evidence was very strong that this limited and local shelly clay at Chapelhall, taking all we know of it, was not in any true sense a marine bed. The alternative suggestion was that "The layer containing these shells may have been transported (most likely in a frozen condition) by the ice-sheet, as in many other instances to which he referred. This appeared to be by far the most probable account of it; its position in the track of the old ice-sheet, and in front of an obstruction presented by the highest rising ground in the district, the nature of the organisms, and the very colour of the clay (as reported) being different from the clays of the immediate neighbourhood; all pointed to this conclusion. He therefore urged that this Chapelhall clay should no longer be cited as a proof of submergence.

An interesting discussion followed.

CORRESPONDENCE.

THEORY FOR "CLEAT" IN COAL-SEAMS.

SIR,—It must surely be admitted by students of the Coal-measures in every country, where coal-mining is carried on to any extent, that coal-seams are the most persistent in extent of area, most uniform in composition and in homogenity of any strata of the series; and therfore may justly be considered the *typical* beds of it. The *master-joints* or "cleat" of coal are much more regular than those of any other strata; and I think Coal-beds were much more likely to shrink and crack *evenly* than the less persistent and ever-varying associated shales, clays, and sandstones. The least-disturbed Coal-areas exhibit the best-developed or most regular and typical "cleat." Thus, if "cleat" was formed or produced by shrinkage of the mass in cooling, due to elevation following deep subsidence (which I think is the generally accepted opinion as to what caused "cleat"); why, it may, and has often been asked, does the "cleat" (the direction of the main joints) usually run roughly N.N.W. and S.S.E., this being the general trend, not only in England but in the United States, and probably in many other countries? I have not come across any good reason in explanation of this fact, but reflecting on the point it occurred to me that possibly the following theory might account for it.

As the Coal-measures were upheaved or elevated at the end of the Coal period. the rocks would cool and consequently contract to some extent, and in contracting would crack, and thus the joints would be formed; but the cause of the joints taking lines roughly parallel with the earth's axis, or closely corresponding with *polarity* or *longitude,* I venture to think may have been due to the increased rotary velocity or greater centrifugal force acting upon the coal-seams as elevation proceeded—as they got further and further away from the earth's centre and so became more liable to open, split, and expand: in other words, *the tensional strength of the coal gave way along approximate N. and S. lines due to increased velocity of travel as a consequence of elevation and cooling.*

Mathematicians and physical scientists may possibly demonstrate my theory to be contrary to the laws of natural science. If they do, we must then look for some other explanation of the phenomenon of "cleat." At any rate it is hoped that this communication will be accepted or rejected on its merits or demerits, and that it will call up some criticism.

W. S. GRESLEY, F.G.S.

ERIE, PA., U.S.A., 11*th Aug.*, 1892.

A BED OF PEAT IN LONDON CLAY?

Sir,—I observe in the July Number of the "Journal of the Society of Industrial Chemistry" a notice of a short paper in which the use of the term "London Clay" is erroneous, or at least appears so to me. The writers mention and describe a bed of peat at the works of the New Thames Tunnel "underlying the London Clay." As the bed in question is only 12 feet below the surface this is scarcely possible unless there is some misprint. The peat is "composed chiefly of branches and trunks of trees, twigs, etc. It is about two feet thick."

It seems to me that the writers are referring to one of the exposures of the buried forest or peat bed so common around the southern coast of England. The error, if such it is, would be of slight importance were it not for the concluding sentence, "it has geological interest as showing that at a period *anterior to the formation of the London Clay* an abundant growth of trees and shrubs extended from some distance inland right down to the water's edge in this locality."

It seems from this that the writers have also mistaken some recent and local stratum for the "London Clay" of geology. Perhaps some one nearer to the spot than I am can correct the error if there is one. E. W. Claypole, D.Sc., B.A. (Lond.)

Buchtel Coll., Akron, Ohio.

Note by Mr. F. C. J. Spurrell, F.G.S.

Sir,—I have read Mr. Claypole's letter. His surmise that the bed of peat 12 feet below the surface at the spot described is part of the recent forest-beds of the South of England is correct. It is above and in no way connected with the London Clay. This term, applied to the alluvial blue clays of the Thames, was in use in Brunel's days, and I should think the author of the paper referred to had been reading up some old accounts of embanking, etc., of the last century, when the *blue* clay, wherever found, was supposed to be the same as the mass underlying London. F. C. J. S.

Belvedere, Kent, 24*th Sept.*, 1892.

THE PHOSPHATIC CHALK AT TAPLOW.

Sir,—Since, so far as I am aware, none but microscopic fish remains have been recorded from the Taplow phosphatic chalk, it may be of interest to mention that, on July 8th last, I found in the 8 ft. bed at Taplow Court Lodge, described by Mr. Strahan (Quart. Journ. Geol. Soc., 1891, p. 356), the detached crown of a shark's tooth $\frac{5}{8}$ inch long. Although this is insufficient for accurate determination, Mr. A. Smith Woodward informs me that it most nearly resembles the form of tooth described by Agassiz as *Odontaspis subulata*, but is rather large for that species.

Bernard Hobson.

Geological Department, Owen's College, Manchester.
September 13*th*, 1892.

ON THE GENUS *TREMATONOTUS.*

SIR,—During the preparation of my paper on *Trematonotus*, published in the GEOLOGICAL MAGAZINE for August, I much regret having overlooked a valuable monograph by Professor Lindström, "On the Silurian Gastropoda and Pteropoda of Gotland" (*K. Svenska Vet.-Akad. Handl.* 1884), containing descriptions and figures of two new species of this genus, *viz.: T. longitudinalis* and *T. compressus.*

The former of these shells, to which my remarks will now apply, was stated by its author to resemble so closely *Bellerophon dilatatus* of James de Carle Sowerby that he would have identified it as such, but for the absence of any mention of dorsal perforations either in the original description or in McCoy's later account of the same species (Pal. Foss. 1852, p. 309).

It was reserved for the Reviewer of Professor Lindström's work (Dr. G. J. Hinde) to point out that "*T. longitudinalis* is identical with *Bellerophon dilatatus*; as the type specimen of this form shows distinct traces of the characteristic apertures on the dorsal keel" (GEOL. MAG. 1885, p. 39).

An examination of the Sowerby type did not convince me that this evidence was complete; but Dr. Hinde has recently shown me another specimen of *B. dilatatus* in a better state of preservation, belonging to the Jermyn Street Museum (No. vii. $\frac{1}{31}$) which possesses unmistakably the elongate perforations, so that all doubts, in my mind, are now removed as to the true nature of this classical species.

With regard to my *T. Britannicus*, although more ovate in contour and very deficient in its umbilical characters, through pressure, yet its ornamentation and perforations are so like the Swedish specimen that they may be looked upon as practically the same species. The effect of this will be that *T. Britannicus*, like *T. longitudinalis*, will fall into synonomy under the older name of *T. dilatatus.*

In conclusion, I wish to record my indebtedness to Dr. Hinde for assisting me in this determination, and to assure Prof. Lindström how sorry I am that his monograph escaped my attention.

NAT. HIST. MUSEUM,
October 12*th*, 1892.

R. BULLEN NEWTON.

ON THE FLEXIBILITY OF ROCKS.

SIR,—With regard to the localities in Durham at which Flexible Limestone occurs. I find that Prof. G. A. Lebour refers to several in his "Outlines of the Geology of Northumberland and Durham." At the time of writing the description of this rock published in the March Number of the GEOL. MAG. (1892), I had no opportunity of referring to this work. Prof. Lebour kindly informs me that the variety from Marsden loses its flexibility after being kept in a dry place for some time. My specimens from Sunderland do not appear to have undergone any loss of flexibility as yet.

ROYAL COLLEGE OF SCIENCE,
October 3rd, 1892.

GEORGE W. CARD, A.R.S.M.

THE CONISTON LIMESTONE SERIES.

Sir,—The Geologists Association visited the exposures of the volcanic rocks on the flanks of Roman Fell under my guidance, on the occasion of the Long Excursion to Cumberland in 1889, when they had an opportunity of examining the sections which it was the chief object of my paper on the Coniston Limestone series to describe. Other field geologists have at different times examined the same facts with me. The sections are not very easily found, and the relation of the various rocks to each other is certainly not very clear at first sight. But after repeated examinations of the Ordovician rocks of the whole of the area enclosed by the Pennine Faults it becomes evident that there are three well-marked horizons on which volcanic rocks occur. The highest of these is intimately associated with the base of the Coniston Limestone. The lowest consists of a series of tuffs of subaqueous origin, which are clearly interstratified with argillites resembling the Skiddaw Slates. These are the rocks of the Milburn Series, and are the submarine equivalents of the lower half of the Borrowdale volcanic series. The third includes the very peculiar set of volcanic rocks which I have described as the Helton Moor volcanic series. These are quite different in lithological character from either of the other two, and as they cannot be newer than the first, nor older than the second, they must be of age intermediate between the two. All three types occur side by side on Helton Moor, as I have pointed out already on several occasions. It is in association with these that the shales of Lycum Sike occur. We have the best possible authority for the occurrence in these beds of Lycum Sike of *Trematis corona*, which occur also in the shales belonging to the Coniston Limestone Series. *Trematis corona* is here, therefore, not available as a characteristic fossil, for the beds of Lycum Sike are separated by a considerable, if unknown, thickness of other rocks from the true Coniston Limestone Series[1] This latter overlies the rocks of Dufton and Knock Pikes, while the beds of Lycum Sike lie at an unknown distance below.

Much more is involved in this question than a mere error of delineation, which no one who has attempted to map the complicated area in question could well avoid, here or there.

Unless I am very greatly mistaken it is the middle and the upper group of these volcanic rocks which occur at the northern end of the exposure near Melmerby, and it is the same two groups which form the volcanic groups on the north-east side of the Lake District. And, furthermore, I strongly suspect that there is a considerable unconformity between the two higher, or Bala, volcanic groups, and the Arenig and older rocks upon which they lie in Cumberland.

I have little doubt that the Ordovician tuffs of the Craven area also correspond to those of Helton Moor and Dufton; but whether the Ingleton Green Slate series lies unconformably below these, or whether it represents the materials of the Milburn series mingled with detrital matter from the seaward margin of the Borrowdale volcanoes will probably long remain a matter of opinion.

---

[1] I regret very much that I did not write to Prof. Lapworth regarding what I understood him to say about the two horizons of *Trematis corona* at Girvan. I did not like to trouble an exceptionally busy man upon a matter that I thought he had *already stated* quite clearly. The error is mine.

In conclusion I may state that I should be glad to conduct a party of field geologists over the areas here referred to if the excursion can be arranged for the summer months. If Mr. Marr should care to be of the party, so much the better.

EDINBURGH MUSEUM OF SCIENCE AND ART, J. G. GOODCHILD.
10th October, 1892.

SHAPES OF SAND GRAINS.

SIR,—It is interesting to find that my friend Mr. Reade admits the rounded sands in the Glacial deposits at Moel-y-Tryfaen "may be treated as erratics."

This view has been held by many glacialists of the anti-submergence school for years. In a paper read before the Liverpool Geological Society in December last, I stated that under the microscope the glacial sands found under the cliffs bounding the Mersey were almost undistinguishable from those on the shore.

But this fact gives no support to the belief that marine conditions obtained during the deposition of those sands. It does not follow that the sands have been rounded by marine action at all.

It is particularly unfortunate that Mr. Reade should have cited the sands "which he has been living on and working in as an engineer for the last twenty-five years" as examples of sea-worn grains.

Not only is the shore skirted by sand dunes whose bases are washed by the tide, but the grains themselves have most probably been derived from the Triassic and Permian rocks which form the solid geology of the district.

The remarkable roundness of grain which characterizes many beds in these formations is well known.

Not less striking than the roundness is the uniformity in size of the grains in some beds. Some agent has been at work which is capable of sifting.

Through the kindness of various friends I have received specimens of sands from many parts of the Desert of Sahara. In one case I had examples from different depths at the same place. The underlying grains are small in size, fairly angular, and contain a large proportion of ferruginous grains. The upper layer is composed of larger grains, extremely well rounded and very uniform in size. In wind-borne material we should expect a sifting due to the varying resistances offered to the wind by the sand particles.

"Desert sands," according to Mr. Reade, "are of course out of the question in glacial geology;" but in the present case it is possible that "desert sands" of a former period may not be "out of the question" and the roundness of grain may have little importance in Glacial Geology. J. LOMAS.

UNIVERSITY COLLEGE, LIVERPOOL,
October 13th, 1892.

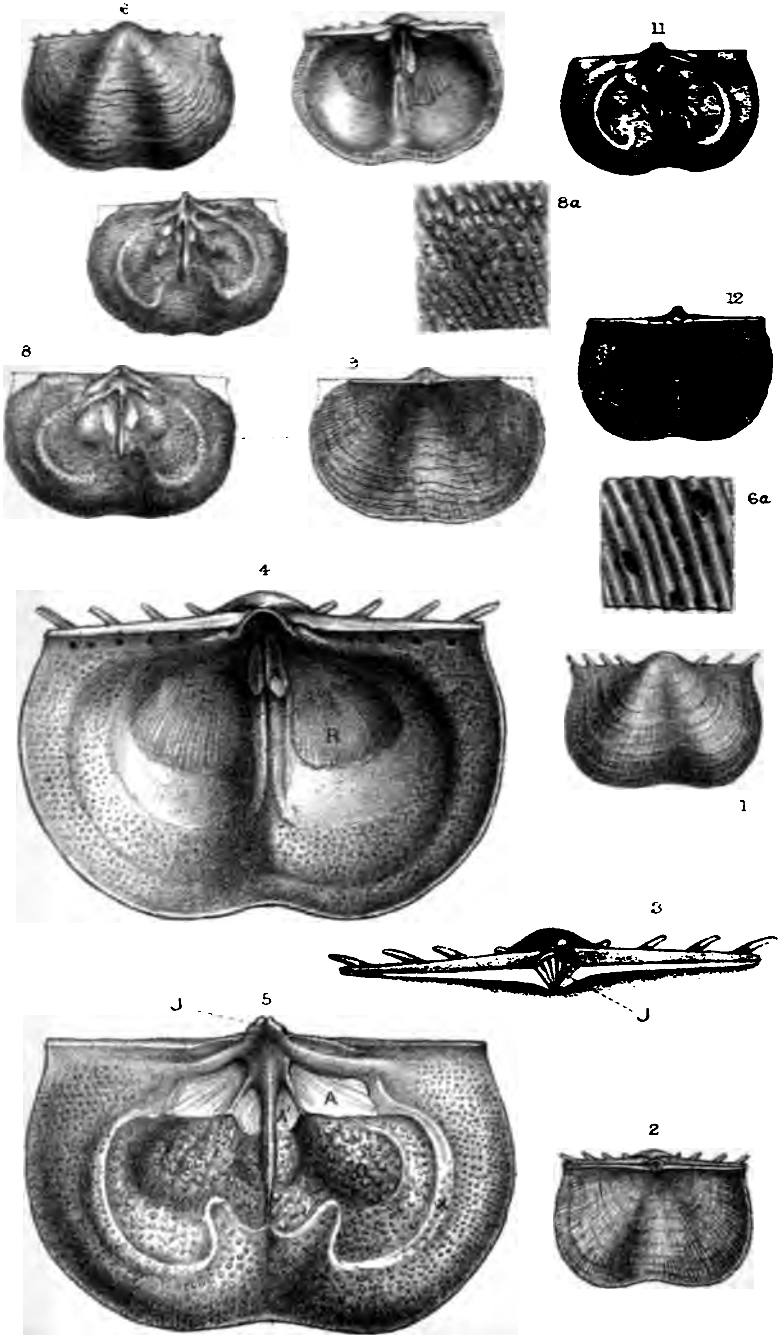
MISCELLANEOUS.

THE DIVINING ROD AGAIN.

Every now and again public attention is drawn to remarkable discoveries of water, obtained professedly through the medium of the Divining Rod. We have on former occasions referred to the use of this rod in the search for minerals as well as water, and attention was lately drawn to the subject in "Natural Science" for June, p. 253. More recently there was an announcement in the "Morning Post," of an astonishing discovery of water at Fishborne and Wootton, in the Isle of Wight, "by the successful use of the Divining Rod." Referring to this matter in the "Isle of Wight County Press" for September 24th, Mr. G. W. Colenutt remarks that previous attempts had been made to get water by sinking wells in the *impervious clays* of the Osborne Beds; the 'Diviner' went to the top of the hill where there is a capping of plateau gravel some twenty feet in thickness. This gravel forms a first-rate reservoir for the surface soakage, which is partly upheld by the Osborne and Bembridge clays, and partly thrown off in the form of springs. The 'Diviner' advised digging *in the land of springs* and—water was found! Mr. Colenutt observes that the usual dramatic incidents took place; but Geology cannot offer any explanation of the grand *finale* of the workmen "rushing out of the well in order to avoid the water."

A NEW GEOLOGICAL MAP OF SCOTLAND, by Sir Archibald Geikie, D.Sc., LL.D., F.R.S., etc., has just been published by John Bartholomew & Co. The scale is ten miles to an inch, and the topography is based on the latest Ordnance Survey. The geology, embodying the latest work on the Geological Survey, summarizes our knowledge up to date; so that the map, together with the concise Descriptive Memoir that accompanies it, furnish us with an excellent index to Scottish geology. The colours are very clear, and they show many divisions in the old Highland Schists (termed Dalradian), as well as the Lewisian Gneiss, Serpentine, etc. Cambrian, Silurian, and succeeding formations are duly represented, as well as many varieties of Igneous rocks. A number of longitudinal sections illustrate the structure of the country. It should also be mentioned that parts of the N.E. of Ireland, and the adjoining tracts of Cumberland and Northumberland are likewise coloured geologically. The price of the map, folded in cloth case is only 6*s*.

EXPLORATION IN BRITISH EAST AFRICA.—MR. JOHN WALTER GREGORY, B.Sc., F.G.S., one of the Assistants in the Geological Department of the British Museum (Natural History), Cromwell Road, has obtained permission to accompany, as Naturalist, the expedition led by Lieutenant C. H. Villiers (Royal Horse Guards) to Lake Rudolph, East Africa. The route taken will be from Kismahu, at the mouth of the Juba River, to Barderah, thence to Lake Rudolph, the shores of which will be explored, and the party will return across Somali-land to Berbera, opposite Aden. The country is new, and valuable results are sure to reward so able a Naturalist as Mr. Gregory.



au & Highley del et lith. West, Newman imp.

Chonetes Pratti. Davidson.
Carboniferous Rocks Western Australia.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IX.

No. XII.—DECEMBER, 1892.

ORIGINAL ARTICLES.

I.—DESCRIPTION OF THE CRETACEOUS SAW-FISH *SCLERORHYNCHUS ATAVUS.*

By ARTHUR SMITH WOODWARD, F.L.S., F.G.S.

IN the "Catalogue of Fossil Fishes in the British Museum" (pt. i. 1889, p. 76, pl. iii. fig. 1), the imperfect rostrum of a Selachian fish from the Upper Cretaceous of Mount Lebanon was described under the new generic and specific name of *Sclerorhynchus atavus*. Presenting some resemblances to the rostrum both of the typical saw-fish (*Pristis*) and of *Pristiophorus*, hesitation was expressed in determining the systematic position of the genus to which the fossil pertained; but from the apparently complex nature of the rostral cartilages and the absence of extended prepalatines, it was deemed advisable to place the fish provisionally in the family of Pristidæ. A further description of the extremity of the rostrum in 1889,[1] though pointing to no definite conclusion, also appeared to favour the same view; and the unexpected discovery of another piece of rostrum among the Teleostean fishes in the British Museum at the same time led the writer to hope that the trunk of *Sclerorhynchus* might soon be identified. A careful study of the new specimen in the light of other Lebanon fossils in the British Museum, has at last realized this hope, and the affinities of *Sclerorhynchus atavus* may now be discussed on the basis of a tolerably complete skeleton.

As some of the principal specimens under discussion have already been described and figured, it will suffice on the present occasion merely to publish the accompanying restored outline of the fish (see p. 531). The trunk proves to be that already described under the name of *Squatina crassidens*;[2] and the discrepancies in the dentition and branchial apparatus between this fish and the typical *Squatina*, noted in the original description are thus explained. The absence of all indications of the freely ascending portions of the pectoral arch is also noteworthy in this connection; though the arch is not well shown under any circumstances.

ENUMERATION OF SPECIMENS.

Before, however, dealing with the skeletal characters of *Sclerorhynchus*, it is necessary to state precisely the nature of the evidence by which the rostrum and trunk are proved to pertain to one and the same fish. The specimens are three in number, all in the British Museum, and may be enumerated as follows:—

---

[1] Proc. Zool. Soc. 1889, pp. 449–451, woodcut.

[2] Catal. Foss. Fishes, B.M., pt. i. 1889, p. 69, pl. ii.

(1) No. 53663. A much crushed rostrum, showing part of the mouth at its base, having teeth identical with those of the type-specimen of *Squatina crassidens*, and also one complete propterygial cartilage of the pectoral fin identical with that of the same type-specimen.

(2) No. 49518. Imperfect abdominal region identical with that of *Squatina crassidens*, showing patches of large, strongly calcified tesseræ, exactly resembling those of the rostral cartilages of *Sclerorhynchus*, and unknown in any other Lebanon fish.

(3) No. 49547. Middle portion of fish, undoubtedly *Sq. crassidens*, displaying teeth and pectoral propterygium identical with those of No. 53663, and showing a detached patch of the characteristic rostral cartilage.

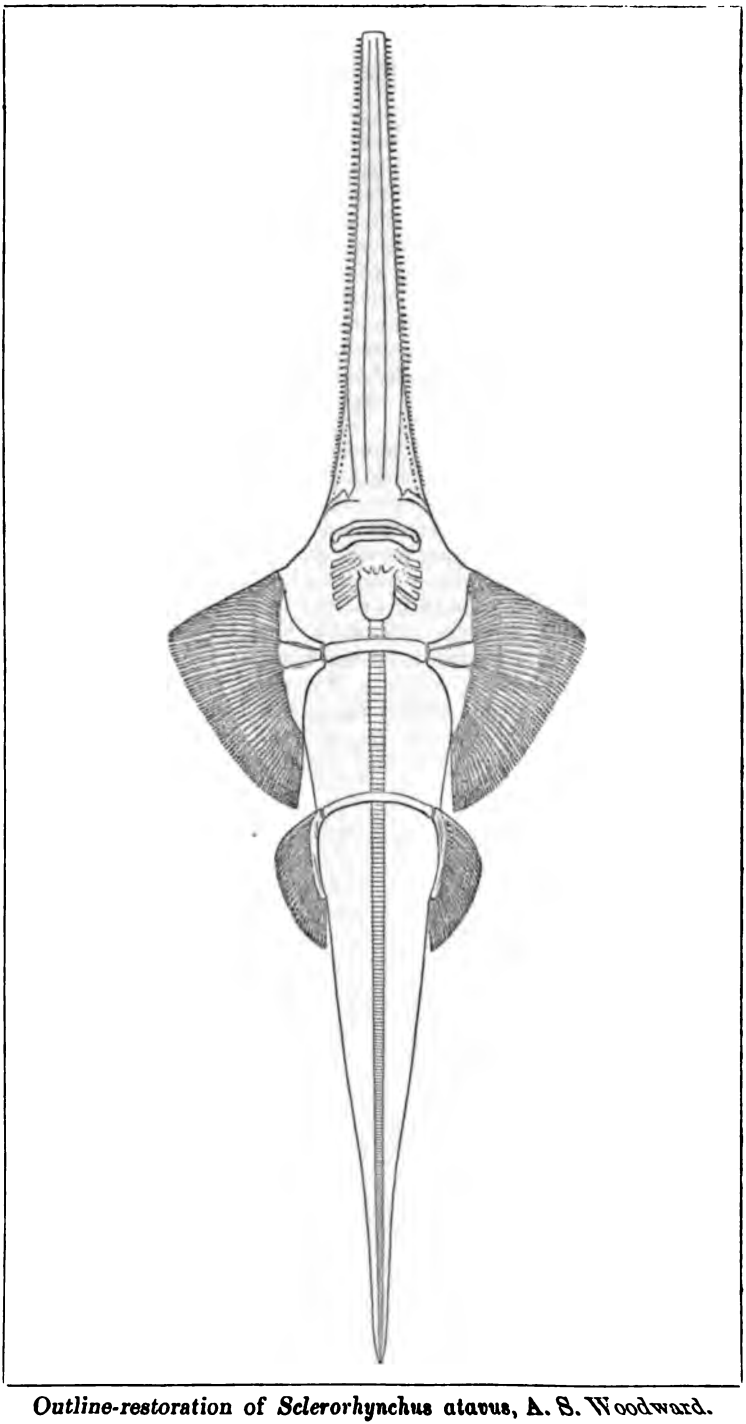
The general form and proportions of the trunk in the restoration are based upon the type-specimen of *Squatina crassidens*; while the proportions of the rostrum are inferred from the type-specimen of *Sclerorhynchus atavus*, and the tip of a small rostrum of a similar kind in the Paris Museum of Natural History.[1] Some details are added from other imperfect fossils noticed in the British Museum Catalogue.

DESCRIPTION.

Head.—The rostrum seems to have occupied not less than one-third of the total length of the fish, and its length equals about five times its maximum width at the base. If the Paris specimen be correctly interpreted as the extremity of the snout, the median rostral cartilage is shown to extend throughout its length; and the pair of broad lateral cartilages, fixed at the base between the anterior part of the nasal capsules and the narrow median cartilage, soon begins to occupy the whole of the space between this cartilage and the toothed margin of the blade on each side. The integument extends up the base of the rostrum in such a manner that there is no sharp line of demarcation between the head and the "saw"; while a gradual passage can even be observed between the ordinary dermal tubercles of the body and the elongated teeth arranged in a single regular series on each lateral rostral border. None of these teeth are fixed in sockets of the cartilage; but each comprises a high, round, crimped base, fixed in the skin in the usual manner, with a long, enamelled, exserted portion, compressed to an anterior and posterior acute edge. On the anterior border of each nasal capsule there is a sharply-defined, well-calcified triangular extension, apparently to be regarded as an abbreviate prepalatine cartilage; and amid the indecipherable remains of the cranium behind, the form and proportions of the jaws are distinguishable, as given in the figure. Several series of teeth seem to have been simultaneously functional in the jaws, and they are uniform in character. Each

---

[1] Proc. Zool. Soc. 1889, p. 450, woodcut.



Outline-restoration of *Sclerorhynchus atavus*, A. S. Woodward.

About one-fifth natural size. Upper Cretaceous, Mount Lebanon, Syria.

tooth is broad and acuminate, compressed antero-posteriorly, and fixed upon a depressed base; the crown is marked by large vertical wrinkles, and its median portion is more or less produced downwards anteriorly over the root.[1]

Branchial Apparatus.—The branchial arches are only seen imperfectly from below in one specimen (B.M. No. 49546), and this furnishes the evidence for our restoration. The great broad basibranchial plate exhibits at its anterior margin evidence of two pairs of forwardly directed processes, a delicate inner pair somewhat convergent in front, and a larger outer pair divergent. The five hypobranchial cartilages on each side are nearly uniform in size; and the two hindermost pairs are in distinct connection with the body of the basibranchial.

Axial Skeleton of Trunk.—The vertebræ are robust and distinctly tectospondylic, the centra being somewhat deeper than long and depressed-oval in transverse section. The constriction of the vertebral centra is slight. There are traces of slender ribs (not shown in the figure) in the region of the pelvis, but precise details as to their extent and arrangement cannot be ascertained.

Appendicular Skeleton.—In the paired fins the slender cartilaginous rays extend to the outer margin, are articulated at distant intervals, and bifurcate distally except in the most anterior portion of the pectorals. The shoulder girdle is hypothetically indicated in the figure, its remains in all known specimens being obscure; but the basal cartilages of the pectoral fins are well shown in several cases. The propterygium is considerably extended forwards and supports about 16 rays; the mesopterygium is narrow and bears 8 rays; and the metapterygium, much produced backwards, is the largest element supporting not less than 25 rays. The pectoral fins are triangular in shape and relatively large, each much exceeding in breadth the width of the pectoral arch; and their posterior apex almost reaches the pair of pelvic fins. The pelvic arch is slender, and the basipterygium is much elongated, bearing about 22 rays of which the most anterior one is considerably thickened. Of the median fins there are no certain indications, though it seems not unlikely that the little triangular expansion on the left side of the extremity of the tail in the principal specimen of the trunk,[2] will prove to be the second dorsal.

Dermal Structures.—The skin is covered with numerous very small stellate tubercles, some spinous, some indented in the centre, and those on the snout gradually passing into the single paired series of rostral teeth. The lateral borders of the head, the anterior border of the paired fins, and the sides of the tail are also strengthened by much more robust, small, smooth tubercles, closely arranged in a dense cluster.

SYSTEMATIC DETERMINATION.

The Selachian thus described is shown by its vertebral axis to belong to the suborder Tectospondyli; and in the general form of the trunk it makes some approximation to the Squatinidæ, Rhinobatidæ, Pristiophoridæ, and Pristidæ. From the first family the fish is, of course, immediately distinguished by the production of the snout; and from the second family it is likewise separated by the structure and armature of this rostrum. From the Pristiophoridæ it is distinguished by the forward production of the propterygium of the pectoral fin, which would cause the gill-clefts to open on the ventral aspect of the trunk, or at least direct them towards the ventral aspect as much as in the existing Squatinidæ; and there are also important differences in the structure of the snout and the paired fins, the latter in the Pristiophoridæ always exhibiting a great extension of skin beyond the cartilaginous rays, as in ordinary sharks. From *Pristis*, the type-genus of the Pristidæ, the fish now under discussion merely differs essentially (1) in the simple and non-implanted character of the rostral teeth, (2) in the extension of the median rostral cartilage to the end of the snout, and (3) in the relatively short and broad form of the trunk, with the pectoral fins almost reaching the pelvic pair. None of these characters, or any of the minor points to be noted in the generic diagnosis of *Sclerorhynchus*, seem to justify its being placed in a family distinct from that including *Pristis*; and the present investigation therefore confirms former suspicions as to the systematic relationships of the fish.

---

[1] Catal. Foss. Fishes, B.M., pt. i. pl. ii. fig. 4.

[2] Catal. Foss. Fishes, B.M., pt. i. pl. ii. fig. 1.

If so much be admitted, it is evident that *Sclerorhynchus* remains as the most generalized described form of the saw-fishes, and at the same time their earliest known representative. It is, however, difficult to understand how the curiously complex rostral teeth of the typical *Pristis* can have been evolved from an armature similar to that of *Sclerorhynchus*; and it is contrary to current belief to suppose that the much elongated trunk of *Pristis* is not a primitive inheritance from the sharks, but an indirect modification through some almost skate-like form of trunk such as that of the Lebanon fish. So far as known, *Propristis*[1] appears to be an intermediate link from the Lower Tertiary, the ordinary *Pristis*-like teeth in this genus being described as not fixed in sockets in any secondarily developed cartilage on the border of the pair of cartilages of the rostrum. Nevertheless, it must at present suffice to record *Sclerorhynchus* as occupying an undetermined position in the family, capable of definition, but awaiting the discovery of more Mesozoic and early Tertiary genera to elucidate its precise significance.

In conclusion, the following diagnoses may be appended:—

Genus *Sclerorhynchus*.

[A. S. Woodward, Catal. Foss. Fishes, B.M., pt. i. 1889, p. 76.]

Body depressed; pectoral fins relatively large, triangular, extending behind almost as far as the origin of the pelvic fins, and having the propterygium much produced forwards. Rostrum gradually expanding at the base, and supported throughout its length by the median rostral cartilage of the cranium with one pair of lateral cartilages; rostral teeth simple, loosely attached to the skin. Teeth in jaws small, acuminate. Dorsal fins without spine. Trunk covered with minute stellate tubercles, gradually enlarging and passing on the snout into the rostral teeth; the lateral borders of the head, the anterior border of the paired fins, and the sides of the tail strengthened with dense patches of small, robust, smooth tubercles.

---

[1] W. Dames, Sitzungsb. math.-phys. cl. k. preuss. Akad. Wiss. 1883, pt. i. p. 136.

Sclerorhynchus atavus.

1889. *Sclerorhynchus atavus*, A. S. Woodward, Cat. Foss. Fishes, B.M., pt. i. p. 76, pl. iii. fig. 1, and Proc. Zool. Soc., p. 450, woodcut.
1889. *Squatina crassidens*, A. S. Woodward, Cat. Foss. Fishes, B.M., pt. i. p. 69, pl. ii.
1890. *Pristiophorus* (*Sclerorhynchus*) *atavus*, O. Jaekel, Zeitschr. deutsch. geol. Ges., p. 117, pl. ii. fig. 1.
1891. *Pristiophorus atavus*, O. Jaekel, Archiv. f. Naturgesch., p. 43, pl. i. fig. 1.

Type. Portion of rostrum; British Museum.

The type-species, attaining a length of about 0·85. Maximum breadth across the pectoral fins nearly equal to the length of the rostrum, which occupies about one-third of the total length of the fish. Teeth vertically ribbed, at least on the inner face. Pelvic fins more than half as long as the pectorals. Rostral teeth small and regularly arranged, compressed to a sharp edge anteriorly and posteriorly.

Formation and Locality.—Upper Cretaceous (Senonian); Sahel Alma, Mount Lebanon, Syria.

II.—ON THE WENLOCK AND LUDLOW STRATA OF THE LAKE DISTRICT.

By J. E. MARR, M.A., F.R.S., Sec.G.S.

THE beds above the Borrowdale volcanic group, and below the Coniston Flags, have been treated in detail in other communications, but, notwithstanding all that has been written of the higher Silurian rocks of the Lake District, something remains to be said about them. The classification adopted in this paper, reasons for which will be subsequently given, is subjoined:—

Kirkby Moor Flags	=	Upper Ludlow.
Calcareous Beds and Starfish Beds	=	Passage between Upper and Lower Ludlow.
Bannisdale Slates ...	=	Lower Ludlow.
Coniston Grits		
Coldwell Beds		
Brathay Flags	=	Wenlock.

These formations, it is well-known, are found principally in the undulating country to the south of the Coniston Limestone outcrop of the central region of the Lake District, and extend thence in an easterly direction, forming the great bulk of the Howgill Fells, and appearing finally in the neighbourhood of Settle. The Brathay Flags are found in two exposures in the neighbourhood of Dufton, on the west side of the Cross Fell inlier, indicating the probable occurrence of a synclinal occupied by these Upper Silurian strata [illegible]der the newer rocks of the Eden Valley, and an outcrop of the [illegible]ton grits is found on the extreme north of the Cross Fell area, [illegible]ng to the commencement of the Silurian rocks on the north [illegible] the great Lake District anticline. This isolated outcrop is [illegible]ding, as the beds are here only thirty-five miles distant from the strata of the Riccarton group, near Langholm, in Dumfriesshire, so that it is possible that we are here dealing with beds forming the southern limb of a syncline, of which the Langholm Beds form the northern limb.

The geographical distribution, and general characters of the upper groups of the Silurian strata are recorded in the Memoirs of the Geological Survey. Valuable fossil lists are given in these Memoirs, to which reference will be subsequently made, especially to the list appended to the Memoir on the district around Kendal, Tebay, and Sedbergh, edited by Mr. Strahan. As the fossils of the Brathay Flags and Coldwell Beds are there included under the head of Coniston Flags, it will be necessary for my purpose to give lists from the Brathay Flags, and Middle and Upper Coldwell Beds respectively. Several of the fossils recorded in the Survey list are not entered here, as their exact horizon remains doubtful, but the following lists give a fairly complete account of the fossils of the different subdivisions.

BRATHAY FLAGS.[1]

=Zone of *Cyrtograptus Murchisoni.*

Mr. Aveline assigns a thickness of 2,800 feet to the whole of the Coniston Flags, and of this considerably less than half appertains to this lower division, which seldom has a thickness of more than 1000 feet. The flags are very uniform in composition throughout the district; they are of a greyish-blue colour, well laminated, and frequently contain calcareous nodules. On the moorland west of Troutbeck they contain numerous indeterminable brachiopods in the lower portion, where they pass down into the Browgill shales, and these beds may be the meagre representatives of the Woolhope limestone, but the greater portion of the deposit contains fossils of few species, chiefly graptolites, which are abundant enough to show, as is well recognized, that these flags are the equivalents of the Wenlock Beds of other areas, and the same fossils are found in the Wenlock Shales of other districts.

FOSSILS OF THE BRATHAY FLAGS.

Monograptus priodon, Bronn.	Rebecca Hill; Broughton Moor; Brathay; Troutbeck; Stockdale; Cross Haw Beck; Austwick Beck.
—— *vomerinus*, Nich.	Same localities as above.
—— *cultellus*, Törnq.	Austwick Beck.
Cyrtograptus Murchisoni, Carr.	Troutbeck; Stockdale; Cross Haw Beck.
Retiolites Geinitzianus, Barr.	Brathay; Troutbeck; Stockdale; Austwick Beck.
Favosites, sp.	Stockdale.
Actinocrinus pulcher Salt.	Osmotherly Common; near Skelgill.
Aptychopsis (*cordiformis*, Jones and Woodw.) =*anatma*, Salt.?	Rebecca Hill.
Aptychopsis angulata, J. & W.?	Nanny Lane, Troutbeck.
Lingulocaris salteriana, J. & W.?	East side of Long Sleddale.
Discina?	Near Skelgill.
Cardiola interrupta, Brod.?	Leck Beck; Hebblethwaite Gill.
Orthoceras primaevum, Forbes.	Frequently.

---

[1] For use of this term, and those of the subdivisions of the Coldwell Beds, see Marr, Q. J. G. S. vol. xxxiv. p. 880.

The graptolites are those of the zone of *Cyrtograptus Murchisoni.* Other zones of Crytograptus may occur in the higher parts of the Brathay Flags, for the graptolites are usually found in good preservation near the base of the flags only, where the beds are less cleaved, owing to the protection afforded by the hard grits of the underlying Browgill Beds. In this lower part of the flags, graptolites may usually be found in a state of relief, though at Cross Haw Beck they are flattened. At this locality the shales at one horizon have the bedding planes crowded with *Cyrtograptus Murchisoni* in all stages of growth. Some of the forms included in the above list are probably referable to *Monograptus personatus*, Tullb., as more than one species seems to have been included in Nicholson's *vomerinus.*

LOWER COLDWELL BEDS.

= Zone of *Monograptus Nilssoni*?

In the Lake District, the thin deposit of grit which forms the lower division of the Coldwell Beds has not hitherto yielded any fossils, but in the Ingleborough district the flags containing the graptolites of the *Cyrtograptus Murchisoni* zone are succeeded by massive grits (Ac. 2. of Prof. Hughes' sections in GEOL. MAG. Dec. I. Vol. IV. p. 346). In 1887[1] I stated that the well-known Moughton Whetstones were possibly interstratified with the grits, and I find that the geological surveyors[2] record two bands of grit below these Whetstones, whilst the "Wharfe grits" of the surveyors (the same beds as those numbered Ac. 2 by Professor Hughes) immediately succeed them. It is true that the surveyors remark that the "Whetstone-bed belongs to the Upper part of the Lower Coniston Flags," but the line appears to be drawn for convenience where the grits become the dominant beds, and the fossils of the Whetstones indicate a different horizon to those of the Lower (Brathay) Flags. I have recorded *Monograptus dubius*, Suess, *M. Nilssoni*, Barr., and *M. uncinatus*, Tullb.? from these beds. Of these, the most characteristic is *M. Nilssoni*, and the zone may be named after it. The "Wharfe grits" are succeeded by beds which are certainly the equivalent of the Upper Coldwell Beds, so these grits with their Whetstone band represent Lower or Middle Coldwell Beds or both. There is no break betwixt them and the Brathay Flags, and this is important, as we shall see, when we discuss the stratigraphical horizon of the *Nilssoni*-zone.

MIDDLE COLDWELL BEDS.

=Zone of *Phacops obtusicaudatus*.

The extraordinary persistence of the bedding-plane containing *Phacops obtusicaudatus* amongst these calcareous gritty flags has been elsewhere noted, and it is only necessary here to give a list of the fossils which have been discovered in this subdivision. They are:—

---

[1] GEOL. MAG. Decade III. Vol. IV. p. 37.
[2] Geology of the Country around Ingleborough, p. 13.

Phacops obtusicaudatus, Salt.	Coldwell; Troutbeck; Helm Knot, etc.
——— *torvus*, Wyatt-Edgell, M.S. ...	East side of Troutbeck; Helm Knot.
Acidaspis, sp.	Randy Pike.
Cheirurus, sp.	Randy Pike.
Cardiola interrupta, Brod.	Troutbeck.
Orthoceras subannulare, Münst.	Coldwell? Randy Pike?
——— *angulatum*, Wahl.	Coldwell?
——— *originale*, Barr.	Coldwell?
——— *recticinctum*, Blake	Coldwell.
——— *lineatum*, His.	Coldwell.
——— ——— var. *tenuistriatum*, Blake.	Randy Pike.
——— *truncatum*, Barr.	Coldwell.
——— *imbricatum*, Wahl.	Coldwell.

The list of Cephalopods is compiled from Prof. Blake's "British Fossil Cephalopoda." Several of the above Cephalopods occur in the same beds on the north side of Helm Knot, Dent. Many other indeterminable fossils also occur, including several Brachiopods.

UPPER COLDWELL BEDS.

=Zone of *Monograptus bohemicus* (lower part).

I pointed out in 1878 that the fossils found in the beds assigned to the Lower Coniston Grits on the East side of Lune are the same as those found in the strata included in the Upper Coniston Flags on the west side of that river, and that both immediately succeed the zone of *Phacops obtusicaudatus*, indicating that the line of demarcation between grits and flags on the east side of Lune, as drawn by the Geological Surveyors, is much lower in the succession than that which they have adopted in the central portion of the Lake District. The Brathay Flags only are included in the Coniston Flags on the eastern side; the top of these flags, as shown by the fossils, is a more natural place to draw the line, than that adopted further to the west; and it is somewhat unfortunate that the terms Coniston Flags and Coniston Grits have got into such general use, considering the vagueness of the expressions.

Since 1878 a number of other fossils have been discovered in the Windermere country, and although further search would undoubtedly furnish many more species, quite sufficient have been collected to show the correctness of the correlation of the Upper Coldwell Beds of the Windermere country with the gritty flags of the S.W. side of Helm Knot, Casterton and Middleton Fells, Horton-in-Ribblesdale, etc. These beds, in some cases certainly, attain a thickness of about 2000 feet, though elsewhere a smaller thickness is at present measurable.

Fossils of the Upper Coldwell Beds.

Cliona prisca, M'Coy.	Helm Knot; Casterton Fell.
†*Monograptus colonus*, Barr.	Broughton Moor; Windermere, Sedbergh, and Ribblesdale districts.
†——— *Rœmeri*, Barr.	Windermere, Sedbergh, and Ribblesdale districts.
†——— *bohemicus*, Barr.	Windermere, Sedbergh, and Ribblesdale districts.
‡*Spirorbis Lewisii*, Sow.	Casterton Fell; Helmside.
†*Actinocrinus? pulcher*, Salt.	Casterton Fell; Cautley; Horton; Troutbeck.

Protaster sp.	Casterton Fell.
†*Ceratiocaris Murchisoni*, Agas.	Casterton Fell; Helm Knot; Troutbeck; South of Coldwell.
‡——— *robusta*, Salt.	Casterton Fell; High Hollins; Helm Knot.
‡——— *tyrannus*, Salt.	Troutbeck.
§*Encrinurus punctatus*, Brünn.	Middleton Fell.
†*Homalonotus Knightii*, König.	Middleton Fell.
**Acidaspis Hughesii*, Salt., M.S.	Casterton Low Fell; Helm Knot; Galegarth; Ravenstonedale.
†*Phacops Stokesii*, M. Edw.	Troutbeck; Outrake, Ulverston.
*——— *torvus*, Wyatt-Edgell, M.S.	Troutbeck.
——— *caudatus*, Brongn. var.	Troutbeck.
Orthis Lewisii, Dav., var. *Hughesii*, Dav.	Helm Knot.
‡*Dayia navicula*, Sow.	Middleton Fell.
†*Rhynchonella nucula*, Sow.	Middleton Fell.
Orthis parva, var. *avellana*	Horton.
†*Discina Forbesii*, Dav.	Middleton Fell.
†*Cardiola interrupta*, Brod.	Windermere; Sedbergh; and Settle districts.
‡*Pterinea subfalcata*, Conr.	Howgill Fells.
†——— *tenuistrita*, M'Coy	Casterton and Middleton Fells; High Hollins; Helm Knot.
†——— *Sowerbyi*, M'Coy	Helm Knot.
Ctenodonta sp.	Helm Knot.
‡*Tentaculites tenuis*, Sow.	Cautley.
†*Orthoceras primaevum*, Forbes	Horton; Helm Knot; Troutbeck.
‡——— *dimidiatum*, Sow.	Helm Knot.
†——— *subundulatum*, Portl.	Horton; Howgill Fells; Hawkshead.
†——— *ludense*, Sow.	Helm Knot.
‡——— *tracheale*, Sow.	Howgill Fells.
†*Trochoceras giganteum*, Sow.	Horton.

* Not recorded outside the district.
† Recorded elsewhere from Ludlow and Wenlock Beds.
‡ Recorded elsewhere from Ludlow only.
§ Recorded elsewhere from Wenlock only.

NOTE.—No account is taken of occurrences in the Denbighshire Grits and Flags.

CONISTON GRITS.

=Zone of *Monograptus bohemicus* (upper part).

The main mass of these grits, estimated by Mr. Aveline to have a thickness of 4000 feet, is unfossiliferous. Two interesting fossil horizons are found, however, viz., the Winder Grit, described by Prof. Hughes in the Geological Survey Memoir on the district around Kendal, Sedbergh, and Tebay (see first edition, published in 1872), with a set of fossils enumerated in the two editions of that Memoir, which it is not necessary to print here; and the "sheerbate flags" exposed in Pennington's Quarry, on the east side of Troutbeck, which contain the three *Monograpti* enumerated as occurring in the Upper Coldwell Beds, *colonus*, *bohemicus*, *Rœmeri*, along with *Cardiola interrupta* and *Orthoceras primævum*.

BANNISDALE SLATES.

=Zone of *Monograptus leintwardinensis*.

A considerable number of fossils have been found scattered through the Bannisdale slates (whose thickness is given by Mr. Aveline as 5,200 feet). They are recorded from various localities, such as Tebay Gill, Crook of Lune, Bowness, etc., and a list of these fossils will be found in the Survey Memoir previously alluded to. Fossils, though rare, can generally be found in sections where the cleavage has not obliterated the bedding planes as planes of division. Some years ago I noticed *Monograpti* on a slab from Reston, near Ings, preserved in the Kendal Museum, which appeared to me to be *M. leintwardinensis*, and though I was unsuccessful in finding these fossils *in situ* at that locality, I last summer discovered that species of *Monograptus* in decomposed gritty shales not far above the top of the Coniston Grits in Tebay Gill, associated with *Monograptus colonus*, Barr., *M. Salweyi*, Hopk., a species of *Ceratiocaris*, and several lamellibranchs. On my return to Cambridge, I found other specimens of *leintwardinensis*, in a drawer containing fossils from the passage beds between the Bannisdale Slates and Kirkby Moor Flags at Underbarrow, and a specimen from the Crook of Lune, which seems to belong to the same species. *M. leintwardinensis*, then, appears to range through the Bannisdale Slates, and I have not met with it in higher or lower beds.

The lower portions of the passage beds between the Bannisdale Slates and Kirkby Moor Flags are well-known from the occurrence of Starfish in them, whence they are frequently spoken of as the Starfish beds; it may be noted that Starfish also occur at a lower horizon in the Bannisdale Slates. The Starfish beds have yielded a rich fauna at Underbarrow and elsewhere, and their fossils are recorded in Salter's Catalogue of Cambrian and Silurian fossils as well as in the Survey Memoir. Mr. Aveline compares the beds above them with the Aymestry Limestone, and this correlation has been generally accepted. These upper beds are calcareous and contain *Dayia navicula* in abundance.

KIRKBY MOOR FLAGS.

These well-known and richly fossiliferous strata are by general consent referred to the Upper Ludlow. A large suite of fossils from the immediate vicinity of Kendal and Kirkby Moor is preserved in the Kendal Museum, and another in the Woodwardian Museum, and these are recorded in Salter's Catalogue and that appended to the Survey Memoir. Numerous fossils are embedded also in the less known flags found in the synclinal running from Staveley to Tebay, and though many of these are of species occurring in the outcrops of the main mass it would well repay local observers to collect fossils from the flags of this syncline, especially in those places where they pass down into the underlying Bannisdale Slates. It is quite unnecessary to give a full list of the fossils of the Kirkby Moor Flags.

CONCLUSIONS.

It has been stated that the Brathay Flags are generally recognized as the equivalents of the Wenlock strata, whilst the Kirkby Moor Flags are equally generally accepted as of Upper Ludlow age. The upper portion only of the Bannisdale Slates is admitted to be Lower Ludlow by the Geological Surveyors, whilst the lower part of the Bannisdales, the whole of the Coniston Grits, and the Coldwell Beds are referred to the Wenlock. If this be so, we should have something like 10.000 feet of Wenlock strata in the district, and only two or three thousand of Lower Ludlow. I hope to show, however, that the Lower Ludlow comprises all the strata between the top of the Brathay Flags and the calcareous deposit referred to the Aymestry limestone at the top of the Bannisdale Slates; in other words, that the three divisions of the Coldwell Beds, the whole of the Coniston grits, and the whole of the Bannisdale slates excepting the calcareous summit (=Aymestry limestone) are of Lower Ludlow age. My reasons are as follows:—(1) At the end of the period of deposition of the deep-water Brathay Flags which are of uniform lithological character from top to bottom, and of very fine material, there was a marked change producing much shallower water deposits which are comparable in lithological characters not with the Wenlock but with the Lower Ludlow shales of other areas. It is possible that the Lower and Middle Coldwell Beds do represent the Wenlock Limestone of other areas, but I think not, and believe that the Wenlock Limestone is absent, and that these Lower and Middle Coldwell Beds are Ludlow.

(2) On account of the nature of the graptolites found in the Moughton whetstones, which immediately succeed the Brathay Flags of Austwick. The graptolites are *Monograptus dubius* and *M. Nilssoni*. These two species are found in the 'Cardiolaskiffer' of Scania, and *Nilssoni* is limited to the base of the 'Cardiolaskiffer.'[1] These Cardiola Beds are correlated by Tullberg with our Lower Ludlow.[2] Again, in Lapworth's paper on the geological distribution of the Rhabdophora, *M. Nilssoni*, is recorded from Lower Ludlow rocks only in the table showing the distribution of the various species of graptolite, and he speaks of the zone of *M. Nilssoni* as lying between the Wenlock and Aymestry limestones, and forming the Lower Ludlow shales of Murchison.

(3) The fossils of the Middle Coldwell Beds give little or no indication of age, and might equally well be Wenlock or Ludlow; but this is not the case with the Upper Coldwell Beds. These beds have the fauna of the Cardiolaskiffer of Sweden (which, as already stated, is correlated by Tullberg with the Lower Ludlow). But the fossils of the Upper Coldwell Beds themselves strongly support their Ludlow affinities. I have indicated in the list those which are confined to the Ludlow, those which occur in the Wenlock also, and that (I can find but one, and the identification of that is doubtful) which has been elsewhere found in the Wenlock only. I would not lay much stress on this, except as showing that the probabilities are quite as much in favour of the beds being Ludlow as of their being Wenlock; but when we deal with the graptolites we have more certain evidence, for though the three species found in the Upper Coldwell Beds have been recorded from the higher Wenlock strata, they only are found in the abundance in which they lie in some of the Upper Coldwell Beds, in Lower Ludlow strata at home and abroad. Furthermore, some of the fossils limited to the Lake District pass up into the Coniston Grits and even into the Bannisdale

---

[1] *Cf.* Tullberg, Skånes graptoliter. Part I. p. 14.

[2] *Cf.* Aft. ur. geol. Fören. i. Stockholm Förhandl. 1880, No. 59, Bd. V. No. 3.

Slates; but they are not found in the Brathay Flags, and the same is true of a great portion of the other fossils, so that if the list of fossils from Bannisdale Slates, Coniston Grits, and Upper Coldwell Beds be examined, a large number will be found common to the three.

(4) The Coniston Grit fossils have a decided Lower Ludlow facies. So much is this the case that Prof. Hughes remarks of the fauna of the Winder grit "The prevalence of *Rhynchonellæ*, especially *R. navicula*, of *Chonetes lata*, of that round rather than elongated variety of *Orthis elegantula*, known as *O. lunata* or *orbicularis*, and other fossils, would, in Wales, lead one to suspect that we were somewhere about the passage beds from Upper to Lower Ludlow."[1] It is true that an explanation is offered in the Survey Memoir to account for an apparent Ludlow fauna in Wenlock strata, but if all these strata be, as I am attempting to show, Ludlow, no such explanation is needed.

(5) *Monograptus leintwardinensis*, occurring in the Bannisdale Slates, was determined as a Lower Ludlow form by Mr. Hopkinson in 1873.[2]

An interesting point brought out by an examination of the Lower Ludlow graptolite-bearing deposits of the North of England is the great thickness of some of the graptolitic zones of these rapidly accumulated shallow-water deposits, forming a marked contrast to the thinness of the graptolitic zones of Llandovery age in the same area. Thus we find the zone of *Monograptus bohemicus* comprising a group of strata having a thickness of about 5000 feet, whilst a similar thickness is assigned to the strata of the zone of *M. leintwardinensis*. A list of the zones of the Llandovery-Ludlow rocks of the area of the Lakes is appended, with the approximate thickness of the beds of each zone.

Equivalents in Silurian Region.	Zone of	Local Names.	Ft.	in.
LOWER LUDLOW.	*Monograptus leintwardinensis*	Bannisdale Slates	5000	0
	——— *bohemicus*	Coniston Grits U. Coldwell Beds Middle...	5000	0
	——— *Nilssoni*	Lower	1000	0
WENLOCK.	*Cyrtograptus Murchisoni*	Brathay Flags ...	1000	0
TARANNON.	——— *Grayae band*	... ...	to 22	0
	Monograptus crispus	Browgill Beds ...		
	——— *turriculatus*	... ...	to 60	0
LLANDOVERY	*Rastrites maximus*	... ...	25	0
	Monograptus spinigerus	... ...	3	0
	——— *clingani band*	... ...	3	0
	——— *convolutus*	Skelgill Beds ...	7	6
	——— *argenteus*	... ...	0	8
	——— *fimbriatus*	... ...	7	6
	Dimorphograptus confertus ...	... ...	to 25	0
	Diplograptus acuminatus	... ...	2	6

---

[1] Survey Memoir, Geology of the Country about Kendal, Sedbergh, etc., p. 16.

[2] GEOL. MAG. Decade I. Vol. X. p. 519.

III.—On the Occurrence of *Chonetes Pratti*, Davidson, in the Carboniferous Rocks of Western Australia.

By R. Bullen Newton, F.G.S.,
of the British Museum (Natural History).

[Read at the British Association, Edinburgh Meeting, 1892.]

(PLATE XIV.)

THE Government of Western Australia, through their Geologist, Harry Page Woodward, Esq., F.G.S., has recently presented to the British Museum an important series of Palæozoic invertebrate fossils which have been collected from various localities during the progress of the geological survey of that colony.

Since their arrival in this country the majority of the specimens have been figured and described in the Geological Magazine for 1890, by Mr. A. H. Foord, Dr. G. J. Hinde, and Prof. H. A. Nicholson.

Among the Brachiopoda from the Irwin River District are three well-preserved valves of a *Chonetes*, consisting of two dorsals and one ventral, which have not yet received identification from the authors referred to, as they came in a second consignment, and after the description of the first series had been published. These valves belong to one species, though to different specimens; the ventral being deeply convex, possessing a prominent central depression, and internally showing well-defined muscular scars, whilst the dorsals retain in singular clearness the reniform vascular impressions in addition to the usual muscular markings.

Desirous of being able to refer these specimens to some described species, it was necessary to consult the unique collection of Brachiopoda formed by the late Dr. Thomas Davidson, now contained in the British Museum, and which at the present time is undergoing a detailed arrangement. There my attention was drawn to the figured example of a form called *Chonetes Pratti*, which Davidson had described as long ago as 1859, in the "Geologist," and which apparently has never since been referred to either by the author himself or by any other specialist of the Brachiopoda. This type consists of a dorsal and ventral valve belonging to the same animal, and its comparison with the Western Australian specimens has resulted in the fact that in every essential character, both mineralogical and structural, it is identically the same, a point of much interest when it is remembered that the Davidson specimen up to this time has been without locality or horizon. The author's description of this species is included in the Explanation of the Plates attached to his essay "On the Families Strophomenidæ and Productidæ," published in the "Geologist" for 1859 (pl. 4, figs. 9–12, p. 116), and is here reproduced, the words in square brackets being used to connect the meaning:—

Chonetes Pratti.—This beautiful specimen (from the collection of Mr. Pratt) is here given as an illustration of the genus, on account of the admirable preservation of its valves. The specimen is silicified[1] and the valves can be as easily separated as in those of a recent species. Its locality is unfortunately unknown. The ventral valve is very deep, with a longitudinal depression along its middle; the dorsal valve is almost flat, with a small elevation towards the front; both valves are covered with minute striæ. The interior of the ventral valve [shows the] *occlusor* and *divaricator* muscular impressions. The cardinal spines and their tubuliform orifices are here clearly exhibited. The interior of the dorsal valve [shows the] cardinal process, [the] anterior and posterior occlusor muscular impressions, [the] ovarian spaces (?), [and the] reniform impressions. The granular prominences are here beautifully exhibited.

---

[1] This statement requires correction, as on submitting the figured examples to the test of Hydrochloric acid their structure is found to be calcareous. My colleague, Mr. Thomas Davies, F.G.S., has also examined the fractured edge of one of the valves, and he identifies the cleavage planes as belonging to Carbonate of Lime.

To these characters might be added:

(1) That the external surface of both valves, besides being ornamented with very fine radiating striæ, possess subimbricating concentric lines of growth; (2) that the extent of the cardinal line represents the minimum width of the shell; (3) that the granular asperites on the interiors of the valves are disposed in lines as they reach the margins, and they are elongate and perforate, presenting the appearance of short tubular spines; (4) that the external surface of the ventral valve exhibits a number of small orifices placed at irregular distances, which might represent the basal attachments of short spines, a character known to exist in *Chonetes papilionacea, C. Hardrensis*, etc.; and that between the striæ or ribs there occur numerous minute perforations.

The dimensions of the figured ventral valve [not given by Davidson] are as follows:—

Maximum breadth	=27 mm.
Minimum breadth (at cardinal margin)	=24 ,,
Maximum length	=19 ,,
Minimum length	=17 ,,
Depth of convexity	= 8 ,,

Two of the valves from Western Australia represent somewhat larger specimens with the following measurements:—

VENTRAL VALVE.

Maximum breadth	=29 mm.
Minimum breadth	=25 ,,
Maximum length	=21 ,,
Minimum length	=20 ,,
Depth of convexity	= 9 ,,

DORSAL VALVE OF ANOTHER SPECIMEN.

Maximum breadth	=30 mm.
Maximum length...	=20 ,,

The deep median depression appears to be a somewhat rare character in the true *Chonetes* although it is exemplified in some species such as the *C. mucronata*[1] of F. B. Meek and T. V. Hayden. This American form, however, differs in other respects from *C. Pratti* in being widest at the cardinal margin, in possessing a greater number of cardinal spines, and in having its ventral valve of a lesser convexity.

The general collection of Brachiopoda in the British Museum contains a single dorsal valve of *C. Pratti*, labelled "Russia" by Professor Morris, in whose collection it formerly was, which so exactly coincides with the other valves here recorded that I am strongly inclined to think that a mistake was made when he attached this locality to his specimen, more especially as on reference to our Russian Brachiopoda there is no form with which to compare it either structurally or lithologically, nor have I succeeded in tracing anything in literature with which to gain any knowledge as to its probable locality. There is every reason to believe that this supposed Russian valve came also from Australia, and most probably, as suggested to me by Dr. H. Woodward, F.R.S., was sent to Prof. Morris as a part of the "Strzelecki" collection, the fossils of which he described in 1845.[1]

---

[1] Description of some new species of Carboniferous Fossils from the Valley of Kansas River, Proc. Acad. Nat. Sci. Philadelphia, 1858, p. 262 (not figured).

The foregoing remarks may therefore lead to the following conclusions:—(1) That the valves discovered by Mr. H. P. Woodward can be referred, without a doubt, to *Chonetes Pratti* of Davidson. (2) That the Davidson type, *hitherto unlocalized*, was most likely obtained from Australia. (3) That the valve labelled "Russia" came, in all probability, from the same country.

In conclusion, it may be of interest to quote the other Carboniferous fossils identified by Messrs. Foord[2] and Hinde[3] from this same portion of Western Australia, viz. the Irwin River District, which has now produced the *Chonetes Pratti* of Davidson. These species are as follows:—

Productus tenuistriatus, Verneuil; *P. undatus*, Defrance; *P. subquadratus*, Morris; *Spirifera Musakheylensis*, Davidson, var. *Australis*, A. H. Foord; *Syringothyris exsuperans*, Koninck; *Reticularia lineata*, Martin, sp.; *R. crebristria*, Morris, sp.; *Orthotetes crenistria*, Phillips, sp.; *Pachydomus carinatus*, Morris; *Bellerophon decussatus*? Fleming; *Orthoceras*, sp.; *Discites*, sp.; *Pleurophyllum Australe*, Hinde; *P. sulcatum*, Hinde.

EXPLANATION OF PLATE XIV.

FIGS. 1–5.—Reproduction of the original figures of *Chonetes Pratti*, taken from the "Geologist," of 1859, pl. iv. figs. 9–12. 1, 2.—Ventral and dorsal view of specimen. Nat. size. 3.—Enlarged portion of valves, showing pseudo-deltidum and (J) cardinal process. 4.—Interior of ventral valve, enlarged, showing (A) the occlusor or adductor and (R) the divaricator or cardinal muscular impressions. The cardinal spines and orifices are also seen. 5.—Interior of dorsal valve, enlarged, showing (J) the cardinal process; (A, A′) anterior and posterior occlusor muscular impressions; (O) ovarian spaces?; (X) the reniform impressions. The dotted surface represents the granular ornamentation.

" 6–10.—The three valves collected by Mr. H. P. Woodward in Western Australia, natural size. 6, 7, interior and exterior of ventral valve. 6*a*, magnified portion of fig. 6, showing orifices on the ribs between which are the minute perforations. 8, 9, 10, interior and exterior of dorsal valves. 8*a*, magnified portion of fig. 8 showing the arrangement and perforated condition of the spinous asperities.

" 11, 12.—Interior and exterior of dorsal valve of the specimen said to come from Russia, but which in all probability was originally part of the "Strzelecki" Collection from Australia.

[All the six specimens figured are in the British Museum (Natural History) Cromwell Road, South Kensington.]

---

[1] Physical Description of New South Wales and Van Dieman's Land, by P. E. de Strzelecki.

[2] GEOL. MAG. 1890, Pl. VII. p. 151–155.

[3] GEOL. MAG. 1890, Pl. VIIIA. p. 196.

IV.—Notes on the Process of Schist-making in the Malvern Hills.

By Charles Callaway, D.Sc., M.A., F.G.S.

IN the October Number of this Magazine, a paper by the Rev. A. Irving, D.Sc., calls for some comment. The subject, "The Malvern Crystallines," is one which has engaged my close attention during the last seven years, and two expositions of my views have appeared in the Quarterly Journal of the Geological Society.[1] I am glad to find that Dr. Irving accepts my main conclusion—that the Malvern gneisses and schists are of igneous origin; but there are some important details in which he has formed a different opinion. It will not be necessary for me to discuss these differences with any fulness, since my third and final paper, which is nearly ready, treats of some of his more material objections to my views.

One of the most important points of difference is the *origin of the granite-veins*. I hold that they are injected into the diorites, and therefore posterior in age; Dr. Irving regards them as segregatory and contemporaneous. I notice, with some surprise, that Dr. Irving quotes the late Prof. John Phillips in support of his theory. The words of the Oxford Professor, as recorded in the "Geology of Oxford and Valley of the Thames," appear to me to contradict his claim. Writing on the granites, diorites, and other crystalline rocks of Malvern, Phillips says (p. 62):—"Segregation from a fused mass is often regarded as the cause of these irregular mixtures; in several cases, however, the posteriority of felspathic and granitic veins to the masses which they traverse is quite certain. . . ."

Dr. Irving contends for the segregatory and contemporaneous origin of the granite-veins on the following grounds:

(1) Upon the way in which the diorite and the granite "graduate into one another;" and he alleges a case at West Malvern of a "gradation from diorite through a biotite or hornblendic-granite to a very coarse pegmatite."

My experience upon this point lends no support whatever to this alleged graduating. There are few outcrops in the Malvern range which I have not examined, and I have never succeeded in finding a passage between granite and diorite. On the other hand, I have observed hundreds of contacts between those two rocks, in which they were seen to be sharply distinguished from each other, and I have examined scores of these contacts under the microscope with the same result. The supposed "gradation" at West Malvern is probably a case of the action of granite on diorite in contact, of which there are plenty of examples in that locality.

(2) "Upon the way in which the felspathic and the quartzo-felspathic veins ramify in all directions through the diorite."

This might sometimes be the case if the granite was ejected from below. The molten rock would pass along lines of least resistance, which would sometimes be horizontal or even trend obliquely downwards. As a matter of fact, however, a large proportion of the veins are seen to rise from below, thinning out upwards and often forking (see fig. 1, p. 485, Quart. Journ. Geol. Soc. August, 1889). For one vein that runs horizontally, there are perhaps a hundred that are almost vertical.

---

[1] August, 1887, p. 525; August, 1889, p. 475.

(3) "Upon the fact that very often the hornblendic rock is observed to be more completely basic in immediate contiguity with the intrusive veins."

It is true that sometimes there is an aggregation of hornblende or biotite forming a rim to the dyke at the junction with a granite-vein, as I pointed out in 1889 (loc. cit. p. 484); but I hold this to be the effect of the injection of the granite, by which a process of mineral aggregation and enlargement is originated, as had been noticed in other localities by Allport, Bonney, and others. Dr. Irving's theory of these basic rims does not explain why, when the hornblende (or biotite) is segregated from the felspar, it should leave on one side of it a band of plagioclase (mainly), and on the other a band which is chiefly orthoclase and quartz. The segregation of hornblende from felspar has indeed often taken place in the Malvern diorites, but, so far as I have seen, the felspar remains mainly diorite-felspar, viz. plagioclase.

(4) "Upon the very significant fact, that the quartzo-felspathic veins, even when less than an inch in thickness, have a coarsely-grained structure, this being so manifest as to make it impossible to believe that they crystallized in contact with a colder rock after injection into it."

Dr. Irving is justified in attaching importance to this argument. If it stood alone, it would have great weight. But the facts making in the opposite direction are so strong (*loc. cit.* pp. 494, 495) that I think it will not do to attach much value to a fact which may be susceptible of another interpretation. It is likely enough that when the veins were injected, the diorite was at nearly as high a temperature as the granite, so that the veins may have cooled down nearly as slowly as the large masses of granite with which they were in connection. For my part, I find it incredible that masses of potash-granite, hundreds of yards in diameter, should have segregated out of the diorite, that the segregated matter should be as coarsely crystalline in fine-grained diorite as in the granitoid variety, and that veins of segregation should produce the same contact-effects as veins of injection.

A second important detail is *whether schistosity was produced before or after consolidation.* Speaking generally, Dr. Irving says, "before." Speaking generally, I say, "after." The reasons for my view are given in part in my second paper, and will be continued in my next. I confine myself in this article to a brief reference to the "cakes" of quartz or quartz-felspar which occur in some of the more felspathic masses. Dr. Irving supposes that this flattening out into "cakes" took place when the quartz was in a colloid state. I select this case because it may seem to be a strong point in his favour. There is, however, pretty clear evidence that these "cakes" are merely very large "eyes," such as occur on a smaller scale in augen-gneiss.

The rock surrounding them, wherever I have seen them, is sheared into a well-foliated gneiss, with well-marked granulitic structure. Each "cake" forms a nucleus around which the gneissic folia are arranged concentrically; and would appear to be merely a tough mass which has succeeded in resisting the shearing action of the earth-mill. The granulitic structure would of itself suggest dynamic deformation subsequent to consolidation. The sheared rock was originally binary granite of very coarse grain, into which it often passes by imperceptible gradations, and the "eyes" can be identified as the same kind of granite, though they have often become more highly siliceous.

Dr. Irving does not appear to dispute that the *production of biotite in the diorite* is sometimes the result of contact alteration; but he denies that such is always the case at Malvern, and he instances the rock in the large quarry at the north-west corner of Swinyard's Hill. He states that the "kersantite" shows "no progressive alteration" as it approaches the "basic dykes." I should be very much surprised if it did. My induction was that usually black mica was developed in diorite at the contact with the granite-veins. It is true that no granite is visible in this quarry; but it is also true that one of the largest masses of granite (pegmatite) in the Malvern Hills crops out at a little distance to the east, where it forms the ridge of the hill for several hundred yards.

The *sericite-schists* of the south-western spur of the Raggedstone have attracted the attention of Dr. Irving. He thinks they form "a fragment of the lithosphere belonging to a much later stage of development than the rest of the Malvern chain," and he "failed in his attempt to trace a gradual transition from them into the gneissose rocks adjoining these schists." These schists are of extreme interest, and will be fully discussed in my third paper. In this place I may say that I *have* traced a "gradual transition" between them and the coarse-grey diorite, and I am in a position to prove by means of a series of about forty microscopic slides, cut from the diorite, the schist, and the intervening rock, that this highly acidic schist has been formed out of the diorite by a process of crushing and shearing, acting subsequently to the intrusion of the granite-veins and to the solidification of the mixed rocks.

On the *mica-schist* (formed from felsite) of the south-eastern spur of the Raggedstone, I have merely a word to say. Dr. Irving thinks I ought not to apply the term "schist" to this rock; but he does not deny that "cleavage-foliation" is to be seen in it. If there is true "cleavage-foliation" in the rock, surely it is entitled to be called a "schist" in the strictest sense of the word, if the usage of British geologists, from Jukes onward, is to go for anything. But Dr. Irving appears to use the term "cleavage-foliation" in a peculiar manner, since he compares this Raggedstone schist with certain "laminated sandstones, on the lamination surfaces of which a similar deposit of secondary mica has taken place." I cannot for a moment admit that such a comparison is justified by the facts. If Dr. Irving will turn to my first paper (1887, p. 531), he will see that, while some of the passage rock is merely a sheared felsite with secondary mica deposited on the shear-surfaces, the central part of the shear-zone consists of true foliated schist.

Dr. Irving seems to employ the term "*shear-plane*" in a sense entirely different from my definition and description (1889, pp. 476, 477). My shear-planes *do* display a "rough parallelism," and they *do not* "cut through the rock-mass at all angles to the quarry face." Dr. Irving says that his "shear-planes" "are often conspicuously slickensided," and from his description of them, I should be disposed to think that they are merely the effects of crushing and sliding taking place long after the schist-making process was completed. This sort of thing is well-known and well-understood, and has no bearing upon the facts and theories set forth in my papers.

It should be clearly understood that it is impossible to see into the mechanism of the schist-making process in the Malvern rocks without the study of large numbers of microscopic slides. As Dr. Irving has not given us any details of microscopic structure, we are left in the dark as to the evidence on which he bases his conclusions.

V.—ON YORKSHIRE THECIDEA.

By JOHN FRANCIS WALKER, M.A., F.G.S., ETC.

I HAVE obtained a considerable number of specimens of *Thecidium ornatum*, Moore, from the Coral Rag, in the bed containing *Phasianella* (*Pseudomelania*) *striata*; *Pseudodiadema versipora*, *Hemicidaris intermedia*, etc., from a quarry between Ayton and Scarborough. My friend, the late Mr. Charles Moore, F.G.S., gave me some specimens of this Brachiopod from the Coral Rag of Lyneham, Wiltshire, with which the Yorkshire *Thecidium* perfectly agrees in form. This shell, especially the dorsal valve, is plentiful at Ayton, but it is troublesome to find on account of its small size; it is best obtained by washing the marl; occasionally it is found attached to Ostrea. In my paper "On the Yorkshire Brachiopoda," York. Phil. Society Report, 1888, I remarked that a species of *Thecidium* occurs at Suffield, near Scarborough, in the Lower coral rag, generally attached to specimens of *Zeilleria Hudlestoni*. I have lately obtained by washing the sand some perfect shells, and consider that they are probably *Thecidea Moreana*, Buvignier.

VI.—WOODWARDIAN MUSEUM NOTES.

By F. R. COWPER REED.

AMONGST the Carboniferous Crinoidea in this Museum an abnormal form of *Platycrinus pileatus*, Goldf., from the Carboniferous Limestone of Bolland was recently discovered by me whilst cataloguing the collection. This specimen has only four arms and the calyx has suffered a corresponding diminution in the number of its plates. The cup is conical, and when viewed from the base roughly quadrangular: it expands somewhat rapidly so that its greatest diameter is only slightly less than its height. The three basals are unequal in size, and form a rude, quadrilateral, cup-shaped figure which extends a little more than one-third up the sides of the calyx. The point of attachment of the stem is small.

The four radials are large, with the usual expansion above to enable them to accommodate themselves to the form of the calyx, their mean length and breadth being nearly equal. The excavation for the arm occupies more than one-third the breadth, and its depth bears about the same proportion to the length of the plate.

The inter-radials occupy the spaces exactly between the arms, and apparently have two shorter lower sides and two longer upper sides which therefore meet at a more acute angle.

The vault is flattened, quadrate, and composed of a few large polygonal plates each bearing a prominent central tubercle, which is especially large at the base of each arm.

In this specimen the arms are wanting, being broken off close to the calyx.

It has been thought that it might be of use to place on record the occurrence of this abnormal form in view of the discussions still going on in regard to variations in recent types.

VII.—NOTES ON RUSSIAN GEOLOGY.[1]

By W. F. HUME, B.Sc., A.R.S.M., F.G.S.;
Demonstrator in Geology, Royal College of Science.

II. THE LOESS: ITS DISTRIBUTION AND CHARACTER IN S. RUSSIA.

COVERING a vast extent of the southern portion of Russia in Europe, occurs the sandy clay which is commonly known as Loess, whose origin has given rise to the most varied and conflicting opinions. In the course of a visit to the above country, this deposit struck the writer as well worthy of further study, whilst its connection with the Black Earth invited closer inspection. Its distribution and general characters, as regards the greater part of Western and Central Europe, have been dealt with in a most masterly manner by Baron von Richthofen in his "China," chap. v.; but at the Russian frontier his description ceases almost abruptly, and he merely mentions that the Dniester and its tributaries appear to have cut their channels through the Loess.

The statements about to be made apply especially to this deposit as it occurs in the Governments of Podolia, Kieff, Kharkoff, Kursk, Ekaterinoslav, Poltava, Tchernigov, and the Don Cossack country, districts which more or less came under my immediate notice. (For map of region see GEOL. MAG. September, 1892, p. 387.) As elsewhere, so here it occupies the highest position in the geological sequence, lying unconformably on all the principal formations. To the W. of the Dnieper it hides beneath itself the broken and contorted gneisses and granites of the Archæan axis, in S. Ekaterinoslav and the Don Cossack country it covers the shales and sandstones of the Carboniferous, whilst in the more central governments of Kursk, Kharkoff, and Tchernigov it overlies the Cretaceous and the whole

---

[1] For No. I., Cretaceous, see GEOL. MAG. September, 1892.

Tertiary series. Also along a certain definite line running to the north of these governments, it rests upon the Boulder-clays and sands of the Glacial period.

Owing to the numerous studies to which this superficial formation has given rise, its special characteristics have been clearly defined, and have generally proved applicable to Loess in every region of the globe where it is known to occur. These may be briefly summarized as follows:—

Similarity in the size of the component grains.

Want of stratification.

Capillary texture and perpendicular cleavage.

Large amount of carbonate of lime present, either as nodules, as a cementing material, or coating the inner cavities of decayed roots.

Presence of land-shells and Mammalian remains.

The Russian Loess may be defined as a yellow-brown sandy clay, very often rich in grains of quartz and flakes of mica, extremely compact when an attempt is made to dislodge it in large pieces; yet so loosely aggregated as to flow through the fingers on the slightest friction. There are, however, secondary additions of very great importance, amongst which humus and carbonate of lime hold the most prominent place. In pursuing the subject, I propose to take the facts in the order in which I have observed them, reserving a discussion of the theoretical conceptions arising therefrom to the end of the paper.

The town of Kieff is not only remarkable as the centre of the Greek Church, the spiritnal metropolis to which the heart (and generally the steps) of every true orthodox Russian turns during some period of his lifetime, but is also of a peculiar interest from a geological standpoint, owing to the magnificent sections which are here exposed to view. I had the additional advantage of being conducted to the principal points of interest by Prof. Armachevsky, of Kieff University, who, with the kindness so often to be met with in Russia, took a large amount of trouble in introducing the various geological features to be seen in the neighbourhood. It may be briefly stated that the exposures display a complete view of the West Russian Tertiary and Quarternary strata, and serve as a good index to the beds of similar character which cover the greater part of Central South Russia.

The town itself is situated on high ground, 300 feet above the river Dnieper, the frontage to the river being formed by a steep cliff like escarpment. The summit is covered by 70 feet of Loess, which itself overlies a considerable thickness of glacial clays filled with boulders derived from Scandinavia and Finland. This evidence of the relative age of the two deposits is of some interest as bearing upon the origin of the former. A similar relationship has been frequently observed in other countries; Fallon noticed it in Saxony, while Foetterle (Verhand K. K. Reichsanstalt, 1889, pp. 102–104), Stur and Wolff have remarked the same in Galicia. Whilst in general the quartz-grains enclosed in the Loess are similar in size, exceptions are not unfrequent. Thus at Kieff larger rounded grains occur, which may be over one-fourth of an inch in diameter, far exceeding the general average of their fellows.

In a brickyard to the S. of the town a further point of interest is displayed, a point indeed to which Prof. Armachevsky attaches great importance. The higher part of the quarry is formed of a very fine white sand, supposed to be of Miocene age. Its surface had evidently undergone considerable denudation before the superjacent deposits were laid down upon it. These consist of a thick layer of Loess, which is *markedly stratified* at the base, the stratification lines agreeing with the slope of the denuded sand-surface beneath. Prof. Armachevsky regards this as a strong proof of the action of running water, and has pointed out numerous similar cases in his work on the Tchernigov Government, as at pp. 12, 14. Indeed, in almost every exposure mentioned by him in the N. E. of that government the same stratified condition of the base of the Loess is noted, pointing to a different process of deposition during the earlier portion of the period in which it was forming.

At the back of the town, this sandy clay is undergoing rapid denudation, giving rise to very broken ground, the many-branched ravines, which are one of its peculiarities, being clearly marked. This feature, though already noticeable in the upper parts of the Dnieper basin, attains an enormous development on the Steppe plateaux which lie between the town of Ekaterinoslav and the Krivoi Rog hæmatite mines.

In these districts deep gorges are formed under the influence of atmospheric waters, percolating through the extremely porous soil. Possibly owing to the *capillary* texture produced in it by the roots of plants penetrating perpendicularly through it, the Loess tends to split in a vertical manner. This occurs during the hot summer period, then, when the rains come on, the water finds its way down the cracks, and large pieces are flaked off, leaving almost perpendicular walls. These precipitous ravines, piercing far into the table-lands, give to the scenery (paradoxical though it may appear to say so) an almost mountainous character, the general effect being enhanced by the vastness of the setting. To so alarming an extent has this action spread, that the railway joining Ekaterinoslav and the above mines is now, in many places, only a few yards from the edge of the abyss, and special precautions have to be taken to divert the drainage from points which are in most imminent peril. Sometimes the wearing away begins from below, where the Loess meets the river, the ravine then slowly works its way into the plateau branching out into wider and wider ramifications.

At other points, far away from the drainage areas, the Loess blends with the other surface deposits in giving rise to broad continuous Steppe plains, devoted in large measure to the cultivation of cereals, and extending in almost unbroken sequence to the foot-hills of the Carpathians. On the virgin soil not occupied by the agriculturist, the abundance of Euphorbiaceous plants was especially noteworthy.

Having thus briefly dealt with the N.W. and W. parts of the

South Central tract under consideration, we may now examine the conditions prevalent at Kharkoff, the capital of Little Russia. The town, though situated between and on the banks of two important tributaries of the Donetz, has, nevertheless, higher ground both on the N. and W., and a casual inspection shows that Loess here plays an important part. This is especially well seen in a ravine, at the foot of the low hill on which the Technological Institute is situated. The base-rock is composed of a greenish, sandy rock, which is very unfossiliferous, having only yielded a few Bryozoa. It is regarded as Oligocene by Professor Barbot-de-Marny. This rock has been denuded in many places, the hollows being completely filled up with a brown-red Loess deposit. At some points, indeed, on one side of the ravine the escarpment appears to be entirely of greensand rock, while on the other the red clay alone is visible. A closer inspection of this clay shows it to possess a very perfect capillary structure, the tubes being filled inside with a carbonate of lime coating, and being evidently originally caused by similar root fibres to those which still penetrate the soil in all directions. Further up the gully, the colour changes from red to white, the transformation being due to the presence of calcareous concretions, aggregated in such large quantities that they simulate a bed of rubbly chalk. In reality, however, this is merely an exaggerated case of an occurrence which is very frequent, and indeed general in the Loess of Southern Russia, and thus brings it into line with similar deposits occurring on the Rhine, in Austria, and in China. Another variety is displayed here, which demands special attention, as throwing some light on the origin of the Black Earth. A close examination enables us to trace a gradual transition from the ordinary yellow-red sandy clay, through a Loess moderately rich in humus materials, to a small, but distinctly-marked layer of Black Earth, which forms the surface-layer in the cliff-face.

A similar relationship on a far larger scale was observed by me while visiting the Bielgorod district. Here, in a small cutting, or quarry on the Steppe, are to be observed some five feet of ordinary Loess, rich in quartz-grains, surmounted by four feet of dark-brown "Black Earth" (this is scarcely ever truly black, being more usually of a dark-brown colour). The latter also contained an innumerable quantity of fair-sized (one-eighth of an inch in diameter) grains of quartz, which glittered brilliantly in the strong sunlight. Close to the point of junction, no sharp demarcation line could be drawn, little seams, or folia, of Black Earth having been formed in the Loess itself. Such inter-bedding, frequently observed, has led me to the conclusion that Black Earth is really a humus-rich modification of Loess, and other facts tend to confirm this view.

In this connection also an interesting section at Kharkoff may be mentioned. It consists of a hollow in the greensand rock, which has been since filled up by very varying materials. Thus at the base is a soft sandstone, following the slope of the little basin. Above it lies a ferruginous sand, which in turn is covered by true Loess. The upper part becomes very rich in humus, and finally passes into a layer of true Black Earth. The whole is only about three feet in thickness.

The above must not be confounded with a similar occurrence which differs only in the fact that the humus occurs near the base, instead of at the upper part of the Loess. This character is very frequent, and may perhaps have a special significance, but I have been unable to obtain sufficient evidence bearing on this point.

The following conclusions may be formulated:—

1. In general the Russian Loess contains quartz grains of approximately equal size.
2. It is usually unstratified, but in certain districts possesses well-marked stratification at the base.
3. It possesses typical capillary structure.
4. It has a tendency to split in a vertical direction, giving rise to perpendicular walls.
5. It is often very rich in carbonate of lime and humus.

Finally, in its wider sense it may be distinguished—

(A) By its irregular vertical and horizontal distribution.

(B) Its practical independence of the subjacent strata.

It would be interesting to know how far (B) is an absolute truth. It seemed to me that the calcareous concretions appeared to be more common in the districts adjoining Cretaceous outcrops, that in the Permian districts the Loess was redder in colour, perhaps due to an intermixture of Permian red sands, whilst near the Archæan gneisses mica and felspars are more common constituents. Such changes might indeed be due to wind action alone, as these small peculiarities are often observable some distance from the rock outcrop, to whose presence they may have been originally due. Positive proof or otherwise could only be given after long and patient research.

The evidence adduced would be incomplete without some account of the palæontological contents. Indeed, the results are so similar to those obtained in other parts of Europe, that they lend final confirmation to the view that the Loess of Russia is more or less coeval with the Loess of Central and Western Europe.

My own conchological finds were too meagre to enable me to make absolute statements on this subject; but happily evidence is forthcoming from other sources.

One of these, Mr. Belt's "Steppes of Southern Russia" (Q.J.G.S., vol. xxxiii. 1877, pp. 843–862), contains several lists of the shells collected by him while on a short journey in S. Russia. Amongst those mentioned the familiar forms of *Helix hispida*, *Succinea oblonga*, and *Pupa marginata* may be noticed. Another, Prof. Armachevsky's "Geology of the Tchernigov Government," also contains much local information on this point, but being in the Russian language, is not so readily accessible to the general reader. On p. 16 of the latter work a deposit of Loess is mentioned as occurring near the valley of the Desna, in the above government. It contains calcareous concretions, and lies unconformably on the Cretaceous. The following shells were met with: *Pupa muscorum*, *Succinea oblonga*, and *Helix hispida*. After mentioning a large number of similar cases he concludes:—"In the Loess, as we have seen, the shells of mollusca are very often met with, belonging to the species *Pupa muscorum*, *Succinea oblonga*, *Helix hispida*, and *Pisidium Henslowianum*. These usually are found aggregated in special localities. Not seldom also occur in it bones of Mammals, in which I myself have found the remains of *Elephas primigenius*, *Rhinoceros tichorhinus*, and *Equus fossilis*."

The Mammoth remains which are so numerous in the Don area also hail from this deposit. Indeed, so common are such Mammalian finds, that bones are constantly being brought to light in all parts of the country.

Thus, whilst I was staying at Hughesevo, the mining centre of the New Russia Company, Mr. Williams, the mines manager, showed me two large bones which had been obtained whilst constructing a dam in the neighbourhood. These proved to be a femur and a tibia, which from the descriptions given of the other parts which were not preserved must have been those of a Bos. In the same locality I obtained shells of *Pupa*, probably from shape and size, of *Pupa muscorum*.

Again, in the N. of the Kharkoff Government, during excavations being carried out on the estates of a proprietor living near Bielie-Polie, a fine *Equus* tooth was met with. These are but two examples, taken from widely-separated points, going to prove how wide-spread the Mammalian fauna must once have been, and how complete is its annihilation. The fauna of the Russian Loess therefore resembles that mentioned by Braun as occurring in the Rhine Valley, and at Toulouse, while the Mammalian remains no less recall those met with all over the European continental area.

Theories as to the Origin of Loess.

Already, in 1845, this deposit had attracted the attention of Sir R. Murchison, but some of the facts which now with longer research have been brought to light, had then escaped his notice. Thus he will not consent to regard the tchornozem (for under this name he includes both the Loess and the Black Earth) as equivalent to the Rhine Loess, because the latter is only found on the sides and bottoms of the great valleys, whereas the tchornozem is found at all levels without relation to the existing form of the land. He also asserts that it has no terrestrial or fluviatile remains (Russia and the Urals, p. 562). He accounts for it as being fine mud or silt, formed in the sea, and extending southwards from the points where the northern icebergs ceased to advance. The marine shells might have been decomposed during slow elevation by aqueous and atmospheric agency. It must, however, in justice be stated that the possibility of its formation in great lakes is suggested.

Of course, all the evidence at present adduced shows Murchison's view to be entirely untenable, and like the similar ideas propounded by Bennigsen Förder and Fallou for the German Loess, it now possesses a purely historical interest. No doubt it was partly based on the proofs of a greater extension of the Aralo-Caspian and Black

Seas which are so abundant in S.E. Russia. (I have sometimes wondered whether such an extension might be the result of the elevation of the sea-level due to the nearer presence of an ice-sheet, such as has been suggested, if I mistake not, by the Rev. O. Fisher, Dr. Croll, and others.)

A far more important suggestion was that made by Sir C. Lyell for the Rhine sandy clays (Principles of Geology, chap. xvi.). The origin of the materials is attributed to glacial action during the ice-period, and he accounts for the homogeneity of the materials as being due to the same cause. The Loess itself is in reality a *fluviatile* silt deposited in the lower reaches of the river by the action of floods. To account for its enormous extent, and considerable elevation, Sir C. Lyell called in the aid of numerous elevations and depressions, although assigning no particular reason for such important earth-changes.

Prof. Heer (Urwelt der Schweiz. p. 521) held that Loess was sand and mud deposited from glacial torrents.

Mr. Belt, in the work above mentioned, and in numerous others dealing with various parts of the globe, regarded the materials as being due to the flooding which would result if an ice-sheet blocked up the mouths of the rivers and occupied the marine basins. I do not know what grounds there are for believing such a formidable advance of ice to have taken place, and although such a great *lake* lying between the ice-sheet and the southern mountain barrier may explain a few features, the vertical irregularities, the great abundance of land-shells, and the want of stratification still remained as great a mystery as ever. Agassiz (Jahrbuch für Mineralogie, 1867, pp. 676–680), lent his powerful support to the lake deposition view.

It was not, however, until the appearance of Baron von Richthofen's, "China," Vol. I. (see chap. v.) that the great forward step was taken in the discussion of the subject, and an explanation was given which satisfied a large number of then existing difficulties. One important factor, the *wind*, had till then been entirely overlooked, and was now at one bound to explain the formation of some of the most prominent deposits met with on the surface of the earth. But if I understand him aright, Baron von Richthofen demands certain physical conditions, which shall be favourable to Loess formation. They are: 1st. An area, which shall be almost entirely unconnected with the main drainage, to use his own words, an "abflussloses Becken."

2nd. Thus deprived of any means of outlet, the water and its contained salts would settle in the hollows giving rise to salt lakes, which finally by evaporation would become salt steppes. These dry lake-bottoms thus exposed are subjected to subaerial action alone, wind being especially active in the redistribution of the component particles. Loess may also be formed directly by the denuding power of wind action alone, quite independently of the above physical conditions.

In the first case, as soon as an exit was provided, denudation began. *The salts,* previously collected in the soil, are leached out, *and the once barren* Steppe becomes a fruitful plain, and the "wilderness blossoms and rejoices like the rose." Indeed, it but adds another to the numerous examples of contrast which so constantly occur in science, for we should scarcely expect dreary salt deserts to be the spots which should subsequently become the richest corn-growing districts of the world.

Supported as the above theories are, by wealth of argument, by wide experience, and by a vast knowledge of the literature of the subject, they must ever remain as central cores round which the the future development of the question shall crystallize.

Criticisms have, however, arisen especially as regards the want of stratification. Thus in the early part of this year Mons. G. Capus (Comptes Rendus, April 19, 1892), argued that the greater part of the Loess, especially in Turkestan, must have been formed under water. He bases this view on the presence of stratification, variations in composition, and the occasional presence of conglomerates, though he admits that many local but small accumulations may be due to wind action.

Prof. Armachevsky has also propounded a theory for the Russian Loess, based upon his observations in the Tchernigov Government. He expresses himself as follows:—

"The action of atmospheric water in sharply-rising places is double. By energetic and unequal action the mass of mineral parts is carried away and deposited in hollows, or fills up any inequalities. By weak and regular action, waters flowing from gentle slopes as small streams, expend their energies in partly wearing away the irregularities which are to be found in those places, distributing their materials over the places themselves. Such an action of the water in sharply rising places, in connection with the fact that the Loess is only found in such places, permits us to assert that the Loess owes its origin to the action of such scarcely-to-be-observed, gentle streams, which, flowing along the slopes from higher to lower positions, distribute their mineral load along the road. The following facts support this view:—

(1) The underlying stratified clays and sands containing gravel show undoubted proof of the action of water. Loess is closely bound with them, so that it is difficult to believe that they have different origins. The sands and clays are deposits formed on dry land by means of flowing water, the action of which was less regular than when Loess was laid down.

(2) Loess in a horizontal direction passes over into stratified sands.

(3) The underlying strata have undergone great denudation, giving rise to inequalities and deepenings afterwards partly filled with Loess.

It will be seen from the above references how different are the views which have been propounded on this subject. In reconsidering the question, it seems advisable to ask: 1st, what was the geological history of the country before the Loess period, and 2nd, what was its physical history afterwards, viz., at the present day.

1st. In Eocene times the whole, or greater part of S. Russia appears to have been covered by the sea, the shore line being found in the N. of the Tchernigov Government, as evidenced by the broken fragments of Belemnites and Phosphoritic nodules which occur at the base of the Lower Tertiaries. To this period belong the Spondylian Blue Clays of Kieff, similar beds having also been proved to exist in the other governments mentioned at the beginning of this article.

In the Crimea, too, the ubiquitous Nummulites appear to have found a congenial home.

The Northern Continent seems to have slowly advanced southward, for the clays are overlaid by an important series of glauconitic sands, containing amber and plant remains. This succession is well-marked in the Kieff, Kharkoff, and Poltava Governments. Indeed, in Miocene and Pliocene times S. Russia becomes sharply divided into two areas: the Northern half, in which a thickness of unfossiliferous sands (ferruginous or beautifully fine and white), succeed the amber-bearing beds, and separate them from the variegated and freshwater clays which preceded the glacial clays and the Loess; and a Southern half, in which a marine fauna still flourished, although even here, too, the sea was gradually driven back till the present outlines were more or less clearly defined.

Indeed, the facts seem to point to a gradual southward advance of the land area, or, as Professor Suess would have it, retreat of the sea; an advance checked it may be for a time by the presence of an ice-sheet, and the consequent changes involved thereby.

As Professor Suess has pointed out, there appears to be a very intimate relation between the Loess and the Glacial Drift. In N. Russia there is nothing but Glacial Drift at the surface, while in the South the Loess entirely takes its place, but between them is a band, passing into Galicia and Saxony, a band along which the Loess overlies the Glacial Drift, and it is just along this line that the basal stratification is most clearly marked. This relationship appears too striking to be casual, and I am inclined strongly to regard the original constituents of the Loess as being the finely-ground materials due to the combined action of the ice-sheet and the increased drainage activities resulting therefrom. This appeared to be the answer to the question which thus presented itself. Here is a vast deposit in which evidently denudation is now exceeding deposition. Can the original materials of such a deposit have been originally derived from actions which are still proceeding in the same area, or must some other explanation be sought for their origin?

Though the above cause may give a clue to the origin of the materials, other actions may by no means be left out of account. There, are for instance, speculations which may become important if based on sufficient proof. Thus, is the earth sufficiently plastic to be compressed by a mass of ice resting for lengthened periods on the same tract, and if so, would the depression have a corresponding elevation at some distance away? Even a small elevation in the S. of the Russian Empire would be sufficient to convert the central tracts into an "abflussloses Becken;" but I know of no evidence in favour of mountains able to cut off the rain-laden winds such as are demanded by Richthofen. On the whole, S. Russia does not seem to satify the conditions favourable to the origin of a true wind-blown Loess. If such elevation did, indeed, take place, it would be sufficient to convert the region between the ice-sheet and the sea into one vast tundra or series of tundras. Even without such elevation, the effect of the presence of the ice-sheet upon the river-drainage would perhaps be of such a character that we at the present day might be almost unable to grasp its full significance.

2nd. Leaving these speculative ideas, let me ask what are the actual physical agencies which are at work during the course of a year, and what light, if any, they throw on the points under discussion. The autumn may be taken as a convenient starting-point. Immediately the summer heats are over, rain becomes more frequent, thoroughly saturating the porous soil, which during the early frosts is rent in all directions owing to the freezing of the contained moisture. The winter snows which follow, protect the land for four or five long months from further denudation, whilst overhead they are whirled into a fierce blinding metiel by the piercing east wind. It is not till March that the denuding forces are again let loose.

With the return of warmer weather, ice and snow begin to melt. Every small stream becomes a rolling torrent, every river spreads out on both sides into a vast lake area. The flood-gates are opened, and the denuding action that takes place in the upper reaches is only equalled by the deposition which must occur in the lower parts of the river-basins.

One or two examples may show the energy which is thus unlocked at this period. I have seen trickling streamlets which could be crossed at one step in summer converted into rushing torrents 30 feet wide, and some 20 feet deep, bearing away in their mad rush the remains of the wooden bridges which had been thrown over them higher up the stream. Sometimes during summer very curious contrasts may be witnessed. Thus, at the village of Mandreekin, near Hughesevo, three great wooden ice-breakers were standing in a dry bed, whilst near by rose up two massive stone abutments, the sole remnants of what had once been a solidly-built bridge. The only trace of the river consisted of two stagnant pools, separated by a considerable distance of marsh and dry dusty land. This, indeed, is the summer condition of the minor Russian rivers. One more example will suffice. In spring the Psiol regularly overflows its banks, and rowing is indulged in to a great extent by neighbouring landowners (whose property is often to a large extent under water), the only danger being due to the trees which are sometimes completely hidden under the flood-waters. This flooding, again, is the rule with all the Russian streams.

It is remarkable with what rapidity the waters disappear as soon as the summer sun attains its full power. Roads previously impassable become tracks deep in sand, and the wind or the air-currents caused by differences of temperature have abundant material upon which to exert a redistributive action. On the Ekaterinoslav Steppes on a hot day, we have observed as many as ten or twelve dust-clouds (resembling water-spouts when seen at a distance), rushing along over the vast plains, unimpeded by any obstacles, and frequently attaining a height of from 30 to 40 feet.

What the force of the wind sometimes is may be judged from the fact that on some rare occasions the waters of the river Don have been driven back under its influence for a distance of over eight miles, the ships remaining high and dry, while the Sea of Azov is then evidently seen to lie in a saucer-like depression. Such a force is evidently one by no means to be ignored in considering the physical activities which are at present altering the earth's surface.

It is especially interesting in the more hilly districts to see the clouds of dust being driven up the long slopes, shewing the means by which high elevations may be covered with Loess. Thus in the annual cycle the principal physical forces coming into play are—1. Rain. 2. Frost. 3. Rivers in Flood. 4. Wind. With the greater differences of temperature which previously existed, the first three would probably be far more active, that is to say, if the river-beds were defined as they are now.

It will be noticed that our area is now drained by three important rivers, the Dnieper, Donetz, and Don, whose basins separate higher plateaux lands. Thus on the W. of the Dnieper is a Sub-Carpathian table-land, between the Dnieper and the Don is a Central table-land. Finally, to the E. is the Volga table-land. All these exceed 500 feet in height, while the river-basins between them never reach that level. It is very remarkable to notice that each of these rivers is pressing on the eastern edges of the plateaux which abut against them as steep escarpments. Von Buch considered this westward advance of the river-valleys as being due to the rotation of the earth.

The Loess occupies the upper summit of many of these escarpments, and it has seemed to me that the river Dnieper must have cut out its present valley since the Loess period. The matter is one that seems to call for further study. It is remarkable, for instance, that the Dnieper for a long distance follows the line of the Archæan axis, yet having a thin band of gneisses on the left bank. Below Ekaterinoslav it cuts straight across the Archæan rocks, giving rise to the famous cataracts which render the river useless for navigation below the town of Ekaterinoslav. It seems probable that the Dnieper once ran at the point of surface junction between the gneisses and some softer beds, but that now the latter have been denuded and the river has cut its bed deep into the underlying gneisses.

I cannot refrain from further calling attention to the present physical geography of S. Russia. The Crimea elevation with its volcanic hills appears to have served as a barrier against which the land has been piled up, separating the Sea of Azov from the Western tongue of the Black Sea. But this does not explain the striking parallelism between the course of the three southern rivers. It may be only a coincidence, but it may be also that some deeper cause underlies this phenomenon. Not having visited the southern reaches of these streams it would be unwise to start a theory without actual evidence to support it.

At the present day there is still some apparent tendency to Southern advance on the part of the Russian Continent. The eruptive activities in the Taman peninsula are causing elevations which may eventually close the entry to the Sea of Azov altogether. Meanwhile the Don is pouring its mud-laden waters into the northern end of the same sea. Shipping, that within the memory of men now living, could come right up to the town of Taganrog, has now got to anchor 16 miles outside in the roadstead. Von Baer indeed, held that the Azov Sea is undergoing a gradual elevation.

Similarly the N. part of the Caspian Sea is slowly retiring or drying up, and the great rivers, as the Volga and Dnieper, are becoming silted up. This fact was strongly impressed on my mind while our steamer was fast aground for about twelve hours on a sandbank in the latter river, while the peasants apparently standing in mid-stream were only up to their waists in water.

The following may possibly represent the sequence of events:— I. The Loess particles may be originally derived from the finely ground material resulting from the wearing of the subjacent beds by the ice-sheet. II. The same have been deposited in tundra-like depressions under the influence of slowly-moving waters, or by the action of rivers in flood. III. This deposit under more temperate conditions dried up, and was then suitable material for the redistributive action of the wind.

The redistributive actions are still at work, but denudation is rapidly proceeding, giving rise to the broken ground which lends such special features of beauty and even of wildness to such towns as Kieff, Poltava, and Kharkoff. Floods every year transfer Loess to the lower grounds, whereas wind on the contrary tends to carry it higher in a vertical direction. Plants, with their penetrating roots, steppe-rats tarantulas, and worms all help to break up the porous soil, and thus assists the continuance of the redistribution.

The Loess country is, as has been already stated, one of the chief wheat growing districts of the world. It satisfies in every particular the conditions which Berthelot demanded as being favourable for the fixation of Nitrogen (Comp. Rendus, cvii. 20, 852, etc.), viz. a soil of sandy and clayey nature, which admits of free access of air and is not too moist. Also it must have been rich in potash and poor in nitrogen.

Of course the weathering of the granite rocks on the W. of the Dnieper must be constantly adding fresh materials, which, under the action of the wind, will form part, or has helped to form a part, of the Loess as it is met with in those areas. Indeed, I have already mentioned in this connection that in the neighbourhood of the Archæan rocks the Loess appears to be much richer in micaceous materials.

The belief in an ice-sheet and the traces of its action are so widespread that I need scarcely offer an excuse for using it so freely as a primary cause in the above article.

Again, I have been compelled to call in the action of water, either as slowly moving rills, as rivers in flood, or filling tundra-like depressions to explain some of the observed phenomena, especially the basal stratification. Nevertheless, the other facts pointing to a different conclusion are too numerous to allow me to accept Prof. Armachevsky's views, and regard the whole deposit as due to the action of atmospheric waters.

Lastly, I have attempted to review the chief physical influences acting on the region at the present day, and conclude therefrom that the actual condition of the Russian Loess is due to a multiplicity of causes, which have been acting (with greater force, perhaps, in former centuries) through a very long period of time. Not the least of these, as explaining the abundant land fauna and the vertical distribution, is the wind which has full play on the boundless Steppe.

I also trust I have pointed out that behind the origin and distribution of this great deposit lie questions of physical geography of the greatest interest, questions which alone can be solved by a careful and detailed special examination of the country dealt with in these pages.

VIII.—GRANITE.

By THOMAS R. STRUTHERS;
Hon. Assoc. and late V.P. Geol. Soc. Glasgow.

THE commonly accepted theory of the origin of granite is that, in view of indications that it had been subjected to great pressure, it was formed deep in the earth's crust in a molten state, and, after consolidating, thrust up through it, or exposed at the surface by denudation. This theory is not altogether satisfactory, being equivalent to an assertion that a stately building was first constructed and its foundation laid afterwards. Like some other unsatisfactory theories, it has been so often reiterated that it is tacitly assented to as authoritative, on the principle, we suppose, that what everybody says must be true. There are existing conditions analogous to those under which the trappean rocks were formed, as illustrated by modern submarine and subaërial erupted rocks; but the conditions under which primitive granite originated are not now represented in any part of the world. There is little difficulty in tracing the inorganic constituents of all rocks back to granite; but there is no proof that granite was derived from any pre-existing rock.

According to Hutton, the fundamental rock of the earth's crust consists of the reunited *débris* of older continents, which in like manner may have been formed of the reconstructed wrecks of anterior terrestrial areas, and so on backward *ad infinitum.* In interpreting Hutton's theory Sir Charles Lyell, in his "Principles," attributes to him a belief that "alternate periods of general disturbance and repose had been, and would for ever be, the course of nature." *We do not,* however, suppose that Hutton meant to insist *on this illogical* hypothesis, and as it was based only on assumed facts, it may now be ranked among the ingenious speculations which, in early times, preceded the advance of science to such a degree, but hypotheses, however ingenious, have little prospect of being accepted now-a-days, unless based on incontrovertible facts.

It must be admitted, however, that although the first principles of the Wernerian and Huttonian 'theories' of the earth are unsatisfactory, the *hypotheses* of these propounders of the two opposite geological doctrines (we cannot consider them entitled to rank as theories) have been extremely useful in giving an impetus to the accumulation of knowledge and in the search for truth; whilst in the course of their investigations both Werner and Hutton described and explained many geological phenomena, and thus rendered important aid to future explorers, who again did good service to science, even in the correcting of such errors as may have been made by the original observers.

Stratified rocks must originally have been derived from unstratified rocks; and the inorganic constituents of the former may be traced back to granite, while the direct relation of that rock to gneiss, quartzite, mica-schist, and clay-slate, intimately associated with it, is so evident as to leave no room for doubt. It may also be observed that erupted rocks, whether volcanic, or trappean, have apparently been derived from granite, for in common with them it consists mainly of silica, alumina, potash, soda, lime, magnesia, and iron in varying proportions; and according to Beete Jukes, "if we could follow any actual lava stream to its source in the bowels of the earth, we should in all probability be able to mark in its course every gradation from cinder or pumice to actual granite."

The hydrothermal conditions under which granite was formed are generally acknowledged, but these conditions were peculiar to a particular period of the world's history, when a sea of a high temperature overspread its entire surface before any dry land had appeared. The first terrestrial surfaces would necessarily consist of portions of the sea bottom elevated by volcanic agency after it had cooled, consolidated, and contracted. Had no such upheaval taken place there would have been a foundation laid, but there could have been no superstructure of strata. We may also remark that from the circumstance that granite frequently assumes a bedded form, and in many instances contains fragments of the older stratified rocks evidently enveloped when it was in a molten state, and also that it has been observed in junction with them, it would appear that outbursts of the newer granite must have taken place for some time after the elevation of the first dry land, from which the sedimentary rocks had been derived.

The structure of granite indicates pressure during consolidation; but in accounting for this it is not necessary to adopt the current theory of its origin, for the sea, the depth of which we may estimate at two miles, would exert a pressure of several hundred atmospheres. The commonly adopted theory of the origin of granite appears to be based upon the Huttonian hypothesis that "it was elevated from the ocean, raising up the strata before it." This is partly true, for the granitic foundation of the earth's crust must have participated in any upward movement of the superincumbent strata; but there must have been a considerable extent of granite or other primeval rock raised above the sea-level before any strata could be deposited. The bedding of granite must have taken place when the material was in a molten or plastic state, free to flow. The beds are, as a rule, superimposed upon amorphous granite, and have been traced to rents, not only through the subjacent granite, but through overlying gneissose and schistose strata on which they have been spread. The distinction between bedded and amorphous granite is well-known to granite cutters, the former having what they call a 'greek'—a cleavage plane—which we would suppose to be parallel with the bedding, and a key to the extent to which the rock has been disturbed by convulsions affecting the earth's crust. Bedded granite is widely distributed in the British islands, and many other parts of the world. It was known to the early geologists as stratified granite, in accordance with the Wernerian supposition that "granite fell down first from the universal dissolving liquid." Lyell, in his Manual, observes: "Granite often preserves a very uniform character throughout a wide range of territory, frequently forming hills of a peculiar rounded form, clad with a scanty vegetation. The surface of the rock is, for the most part, in a crumbling state, and the hills are often surmounted by piles of stones like the remains of a stratified mass, and sometimes like heaps of boulders, for which they have been mistaken. The exterior of these stones, originally quadrangular, acquires a rounded form by the action of air and water, for the angles and edges waste away more rapidly than the sides. A similar spherical structure has already been described as characteristic of basalt and other volcanic formations, and it must be referred to analogous causes, as yet but imperfectly understood."[1] Lyell gives an illustration from the Sharp Tor, Cornwall, showing a pile of granite consisting of several courses, and presenting the appearance of the remains of successive stratified deposits; but we have no hesitation in saying that it is a fine example of bedded granite originally discharged in successive submarine sheets, and now fractured, weathered, and reduced by the natural forces to which it has been subjected during the course of ages.

The 'tundra,' or moorland of Siberia, extending along the shores of the Arctic Ocean, presents a good illustration of the physical features produced by bedded granite. Here and there the rock rises in smooth, rounded, protuberances above the general level, which is a monotonous flat, covered with moss; and, as might be expected, scarcely a tree is to be seen. There are many things which the commonly received theory of the origin of granite cannot account for; and it is more reasonable, and more in accordance with existing phenomena, as well as with experimental evidence, to hold that it was formed by the cooling of the exterior of our globe under the primeval deep, and by additions due to outbursts of newer granite from the heated interior, the elastic force of which would be brought into action by the contraction of the rocky barrier by which it was environed; while the modifications produced by seismic and volcanic force, together with exposure to destructive chemical and mechanical agencies through long-continued periods must be taken into account in endeavouring to arrive at a correct understanding of its lithological and petrological aspects. Without enlarging on the subject, it may only farther be remarked, that the thickness of the solid exterior of the earth is commonly reckoned to be about 45 miles; and if we deduct 10 miles for the thickness of the stratified rocks (which is practically an over-estimate, for it represents the depth of all the systems, or differentiated assemblages of strata tabulated in the order of time; and the series is nowhere known to exist in its entirety) we have 35 miles of the crust to account for. This is, properly speaking, the 'foundation' of the earth from which have been elaborated, by chemical and mechanical agency, the more superficial accumulations which contribute so largely to the convenience and comfort of the human race.

---

[1] Lyell's "Students' Elements of Geology," 3rd Edition, 1878, p. 552.

Some geologists continue to distinguish granite from the other unstratified rocks by the term 'Plutonic,' and others class it as a trappean rock. Its varieties might more properly be described as Cryptogene (of hidden origin) whatever shades of difference there may be in their composition, if they exhibit evidence of a common origin by their position and structure; for in granitic—let us say cryptogene—rocks there are many departures from the normal type, which consists of quartz, felspar, and mica; the hornblendic or syenitic varieties forming a stepping-stone to the trappean syenites, and indicating a close relationship between the two classes of unstratified rocks under reference.

NOTICES OF MEMOIRS.

I.—The St. Bees Sandstone and its Associated Rocks.[1] By J. G. Goodchild, F.G.S., H. M. Geological Survey.

The author reviews the history of opinion upon the classification of the New Red Rocks of Cumberland and Westmoreland, and then gives the following as the maximum thickness, general succession, and probable equivalents elsewhere of these rocks:—

New Red Series (Upper Division).

	Maximum observed thickness in feet.
(5) Red marls with rock salt and Gypsum	950
(4) St. Bees Sandstone, with the following subdivisions:— (*d*) Waterstones; (*c*) zone of tile red phases; (*b*) dull Red Sandstone with local bands of fine conglomerate and occasional pebbles; (*a*) zone of variegated sandstones. In all	2000
(4*a*) Graduates downward into—	
(3) Gypsiferous marls with local conglomerate at its base...	300
Magnesian Limestone Group.	
(2″) Magnesian Limestone	25
(2′) Plant beds...	150
Lower New Red.	
(1) Penrith Sandstone: the Brockrams	1500

---

[1] Read before the Brit. Assoc., Edinburgh, August, 1892, in Section C (Geology).

EXTENSIVE UNCONFORMITY.

There is a perfectly unbroken downward succession as far as the conglomerate at the base of (3); and, therefore, as (4*c*) is admitted on all hands to be of Triassic age, the remainder of (4) and the whole of (3) must be of Triassic age also; (3) lies indifferently upon either member of (2) or upon the upper part of (1); it is therefore slightly unconformable to the beds below. These are admitted on all hands to be Permian; therefore the break between the Trias and the Permian is at the base of (3). The author considers that the whole of these rocks form the natural basement beds of the Neozoic rocks, and that the dividing line between the Palæozoic rocks and the Neozoic age should be taken somewhere between the Red Rocks of the Salopian type (to which he would restrict the term Permian) and the true New Red, as the term is here employed. He considers that the New Red proper bears the same relation to the Jurassic and Rhætic Rocks that the Upper Old Red Sandstone does to the Carboniferous, and that the Salopian Permian may possibly occupy the same relation in regard to the Carboniferous rocks as the Glengariff Grits do to the Silurians. Some at least of the Salopian rocks may be simply Carboniferous rocks stained by infiltration from the New Red.

The author regards the St. Bees Sandstone as mainly equivalent to the Bunter, and proposes that the term Bunter Marls should be applied to the marls which here (and in Devonshire, etc.) occur at the base of that subdivision.

II.—THE IGNEOUS ROCKS OF THE NEIGHBOURHOOD OF BUILTH.[1] By HENRY WOODS, B.A., F.G.S.

AN account of the geology of the Builth district was given by Murchison in the "Silurian System" (1839), since which scarcely anything has been written on it. A series of igneous rocks, associated with beds of Ordovician age, stretches from near the town of Builth to beyond Llandrindod. In this paper the author confined himself to the southern half of this area, giving a preliminary description of the distribution and characters of the rocks met with, namely, diabase, rhyolite, porphyrite, andesite, and ashes.

III.—ON THE RELATIONS OF THE ROCKS OF THE LIZARD DISTRICT.[1] By ALEX. SOMERVAIL.

THESE rocks include the hornblende-schist, serpentine, gabbro, granite, etc., which the author regards as all belonging to the same period of geological time, and to have segregated or separated out from each other during the cooling of a homogeneous magma.

There seems absolute evidence in the field to show that the serpentine is a non-intrusive rock, that it was the first portion of the magma to cool, and is broken through by all the other rocks, but that it is intrusive into none.

The relations between the serpentine and the diorite and portions of the granulitic rocks are those of segregation, and not of intrusion, as many sections show these rocks associated together in great alternating bands with a concentric-like structure with complete transition varieties, but with no sign of intrusion on the part of either. These concentric-like structures, which are certainly original —due to cooling—have been subsequently displaced and broken up, so that the now isolated portions are mistaken for intrusive tongues of serpentine or included fragments of hornblende. When followed out they resolve themselves into what were once connected masses.

---

[1] *Abstracts of Papers* Read before the British Association, Edinburgh, Aug. 1892.

While the main masses of these rocks have separated out from each other, and cooled in the order of increasing acidity, there also seems absolute proof in the field that the intrusive dykes in the serpentine, consisting of diorite, granite, complexes of these and also of gabbro, are but portions of the uncooled magma of the main masses which were able to penetrate the serpentine.

That the main masses and the dykes are of one and the same age is evident, not only from their mineral composition and lithological aspect, but also from the fact that all these rocks are inter-related—for example, the gabbro and diorite dykes coalesce, and dykes of the former have margins of the latter. The diorite contains inclusions of gabbro, and in some instances inclusions of the latter contain others of the former. The granulitic rocks, diorite, and gabbro occur as a regular interbanded series, and there are also schists of these complexes.

The facts seem to warrant the following conclusions:—

1. That all these rocks belong to one geological epoch; that their relations are principally those of segregation or separation, and in a lesser degree of contemporaneous intrusion on the part of the less basic and more acid portions of the magma.

2. That the olivine portion of the magma now forming the serpentine was the first to cool, followed by the others in the order of their increasing acidity.

3. That the serpentine is a non-intrusive rock, and one into which all the other types of rock have been intruded, the granite intrusions being the latest.

IV.—ON THE PRESENCE OF FOSSILS IN THE "AZOIC" ROCKS OF BRITTANY. By M. CHARLES BARROIS, Comptes Rendus des Séances de l'Académie des Sciences, Vol. CXV. pp. 326–328, August 8th, 1892.

A BED of quartzite containing crystalline scales of graphite is intercalated in the gneiss of Morbihan. This gneiss passes laterally into mica-schists by the disappearance of felspar. It represents the azoic schists metamorphosed by the injection of "granulite." The graphitic quartzite can be followed for a considerable distance both to the north-east and south-west of the Vannes-sheet of the Survey Map, into regions less affected by the granulite. It is then found to be interstratified with mica-schists. M. Barrois has also determined the presence of the same band in the north of Brittany, where the rocks are far less affected by the intrusive granulite and the graphitic quartzite is represented by carbonaceous quartzites and phtanites. These rocks underlie the phyllades de St. Lô, and pebbles of them are found not only in the Cambrian but also in pre-Cambrian conglomerates. The carbonaceous phtanites of this horizon occurring at Lamballe (Côtes du Nord) contain radiolarian remains which have been identified by M. Cayeux as belonging to the group of the Monosphæridæ. These are the oldest fossils known in France, and probably in the world. The discovery is also interesting because it confirms the theory of M. Michel-Lévy as to the origin of the granulitic gneiss.

REVIEWS.

I.—NOTES SUR L'HISTOIRE ET LA STRUCTURE GÉOLOGIQUE DES CHAINES ALPINES DE LA MAURIENNE, DU BRIANÇONNAIS, ET DES RÉGIONS ADJACENTES. Par M. W. KILIAN. Bull. de la Soc. Géol. de France. 3ème s., vol. xix (1891), pp. 571–661.

SUR L'ALLURE TOURMENTÉE DES PLIS ISOCLINAUX DANS LES MONTAGNES DE LA SAVOIE. Par M. KILIAN. *Ibid.* pp. 1152–1160, pls. xxv.–xxvi.

THE first of the above papers contains the results of a series of explorations carried out by M. Kilian, on behalf of the Geological Survey of France, in a portion of the French Alps between the upper valleys of the Isère, the Italian frontier, and the upper valley of the Ubaye, and they are published in advance of a more complete monograph on the subject. The author's researches have been mainly devoted to the band of sedimentary deposits intercalated between the crystalline zones of Mont Blanc and of Mont Rose, which are comprised in the second and third of the Alpine zones of Lory, and referred to, in the recently published work of Dr. Diener on the Structure of the Western Alps, as the "Zone of the Briançonnais."

The author treats first of the stratigraphical succession of the region, and describes the grey lustrous schists, and the calcareous talcose schists, situated beneath the Triassic deposits, which have a great extension between Bardonnèche, Oulx, and Cezanne (Italy), as well as in the Queyras district. In the schists are beds of blackish crystalline limestone, also some quartzites, and in certain localities they are penetrated by numerous intrusions of serpentine. Near the source of the Ubaye these rocks gradually pass down into micaceous schists alternating with beds of gneiss. The lustrous schists were regarded by Lory as of Triassic age, but M. Kilian considers them to be Palæozoic, possibly Carboniferous, or even more ancient.

The Carboniferous rocks of the region form the great anticlinal of the third zone as well as some of the anticlinals of the second zone, and above them are beds of green phyllites, grits, and conglomerates, resembling the verrucano of the Swiss Alps, which from their stratigraphical position beneath the Trias are referred to the

Permian. although at present there are no fossils known from these rocks to establish their real position. Above the supposed Permians is a great series of rocks, the lower portion of quartzites, succeeded by beds of gypsum, dolomites and dolomitic limestones, and coloured schists. The greater part of this series is considered by the author, on the evidence of fossils, to belong to the Trias. but it probably includes fragments of Liassic and Jurassic rocks which have been caught up and involved in the folds of the older strata. The author attempts to show that the beds of gypsum and the dolomitic limestones in this series are merely lateral modifications of the same deposit. so that in some places the gypsum completely replaces the limestones, whilst in others it occurs either in the upper or lower portions of the series.

Next above the Trias, the Lower Lias is represented by dark limestones usually filled with Belemnites, and the Upper Lias by dark schists or shales. The author has traced out a well-marked calcareous breccia in the Lias; and in the Upper Jurassic also, there is a definite band of brecciated red marbles containing Ammonites and Belemnites of the group of *Duvalia*.

The Tertiary rocks in this region consist of Nummulitic limestones and schists, and the existence is proved of a micaceous and quartzitic breccia of the same age, which had previously been considered Triassic.

In a region so disturbed as the Alps, it must be difficult to distinguish between real and apparent overlap and unconformity; the author considers, however, that there is evidence of a real overlap in the Permian rocks, though not of great extent; whilst the overlap of the Triassic strata on the other hand appears to have been very extensive. There is also both an overlap and unconformity between the Upper Jurassic and the Triassic limestones near Guillestre and Castellet. The great overlap of the Nummulitic rocks is established by the fact that these rocks rest successively on the Lias, the Triassic limestones, gypsum, and quartzite, and in the Basses-Alpes, to the south of the present region, on Senonian rocks; thus indicating the existence of movements subsequent to the Senonian, for fragments of these latter are present in the earliest Eocene beds.

The extent and intricacy of the folding and dislocation of this portion of the Alps are very strikingly shown in the various sections figured by the author, and more particularly in the two remarkable photographs (pls. xxv.–xxvi.) accompanying the second paper, which show a natural section of the escarpments of the Nantbrun Valley.

II.—BORNEO: ITS GEOLOGY AND MINERAL RESOURCES. By Dr. THEODOR POSEWITZ. Translated from the German by Dr. F. H. HATCH, F.G.S. (London: Edward Stanford, 1892, pp. 495; with Geological and other Maps.)

A THREE years' residence in Borneo gave the author an opportunity of becoming acquainted with the leading features in the geology of that island; he has also devoted himself to an exhaustive study of the literature of the subject, much of the best information being in Dutch and but little known out of Holland. In the present work he has summarized all that is known concerning the Geography, Geology, and Mineral Resources of Borneo.

The German edition was published in 1889, and although three years have now elapsed, the information brought together will be of great value to all who are interested in the island. Portions of its large area, however, remain wholly unknown to Europeans.

The formations represented, comprise (1) the crystalline schists, the old slate formation of Devonian (?) age, and certain eruptive rocks: these constitute the mountain chains and their spurs, but the rocks, though grouped together for convenience, are of different ages, and they have not been properly separated. Granites, diorites, gabbros, and serpentines occur. Some of the crystalline rocks may be Archæan, and although the Devonian age of certain slates is suggested by their fossils, these are so badly preserved that no exact determination could be made. Certain beds of limestone, sandstone, conglomerate, and slate (2), are grouped as Carboniferous, from the fact that Encrinites, *Fenestella*, *Stenopora*, and a few other fossils have been found in some of the limestones.

Next in point of order amongst the strata recognized, are (3) Cretaceous beds. These are known only over a very limited area. They comprise grey marls and greenish-grey sandstones, and have yielded species of *Avicula*, *Arca*, *Lima*, *Modiola*, *Trigonia*, *Goniomya*, *Pholadomya*. *Hemiaster*, etc.; but their age cannot be said to be very decisively determined.

All the above-mentioned formations are found to occupy portions of the Mountain-land; the highest elevation in which, Kina-balu, is estimated at about 12,000 feet.

The Hill-land, which rarely exceeds 200 to 300 feet in height, is formed of (4) Tertiary strata. The beds are mainly of Eocene age and comprise sandstones and shales with coal-seams, marls, and limestones. These are pierced in numerous places by eruptive rocks, mostly "hornblende-augite-andesites." The Eocene strata have yielded Nummulites, Corals, and Mollusca. Some of the Mollusca may be compared with those obtained by M. Verbeek from the Tertiary strata of Sumatra, and described by Dr. H. Woodward (GEOL. MAG. 1879, pp. 441, 492, 535); there do not, however, appear to be many species common to the two islands. In Borneo there are some later Tertiary strata (Miocene?); but owing to the absence of fossils, their age could not be more definitely determined.

The Plains are covered by sandy clays and conglomerates (5), grouped as Diluvium; and the Marshes are made up of (6), Alluvial formations, or recent marine and fluviatile deposits. Reference is also made to Cave-deposits and to recent Coral-reefs.

A large part of the work is devoted to the subject of "Useful Minerals." These include Coal, which occurs in the Eocene, and also in the so-called Miocene deposits; but chiefly in the former. It occurs in considerable quantity, but has been comparatively little worked. Full particulars are given, with analyses. Gold occurs in both Alluvial and Diluvial deposits, and in the older rocks (No. 1). Diamonds occur in the Post-Tertiary deposits, but have not yet been found *in situ*. Platinum and ores of Antimony, Mercury, Iron, Copper, and Silver, have been obtained. Ores of Lead and Zinc occur, but it is said that they will not pay for working. Various other ores have also been found. The occurrence of Salt-beds is noted, and there are also Warm Springs.

The notes appended to the work by the author should have been inserted in their proper place in the body of the work by the editor, and he would have greatly added to its usefulness if he had provided an index. The chief value of the work will be in reference to the Economic Geology of the Island; but scientific explorers will find it of great service on all matters connected with the Geology of Borneo.

III.—THE STUDENT'S HANDBOOK OF PHYSICAL GEOLOGY. By A. J. JUKES-BROWNE, B.A., F.G.S. Second Edition. (London: George Bell & Sons, 1892.) Price 7*s*. 6*d*.

THE first edition of this work was briefly noticed in the GEOLOGICAL MAGAZINE for 1884 (p. 461). During the eight years that have elapsed much information has been gathered on the subjects dealt with by the author, and he has enlarged his work, more especially with reference to Volcanoes, the processes of Disintegration, Oceanic deposits, Metamorphism, and Mountain-building. Faults and flexures receive additional illustration in the matter of thrust-planes. We are not altogether confident that the author has done wisely to increase the bulk of his volume from 514 to 666 pages. His aim, as stated in the first edition, was to provide a book of modest pretentions, at a moderate price, for the use of geological classes. Even then, with the volume dealing with Historical Geology, the student had to encounter over eleven hundred pages before he had traversed the field of geology traced out for him; and it is difficult to get students to read big books. Be this as it may, the author has brought his work up to date in a most painstaking manner; and the reader will find a full account of the geological agencies now in operation, of rocks and rock-masses, and of the processes which have led up to the present physical configuration of the earth's surface.

The author objects, as others have sometimes objected, to the use of the word Denudation; but to supplant a familiar and well-understood term is no easy matter. One authority has proposed to establish the word 'Abrasion;' Mr. Jukes-Browne proposes the word 'Detrition.' One of the stumbling-blocks introduced into modern Geology is the attempt to change well-known names, whether in Physical Geology, Stratigraphy, or Palæontology. Changes may not affect the student in his days of class-learning, but when he becomes a worker, he must learn the old as well as the new terms, and every addition, whether useful or otherwise, must needs be a burden.

On Glacial subjects the author has enlarged his views, and he is prepared to admit "that land-ice can in some way give rise to the formation of a Boulder-clay." In cases, however, where there is a difference of opinion amongst geologists, care is taken to state the alternative views.

The work is illustrated by 214 figures and two plates; and altogether it forms an excellent and comprehensive handbook for advanced students.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

November 9th, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.

The PRESIDENT announced that the Naturforschende Gesellschaft of Dantzig will celebrate their 150th Anniversary in that town on January 2nd and 3rd, 1893.

The following communications were read:—

1. "A Sketch of the Geology of the Iron, Gold, and Copper Districts of Michigan." By Prof. M. E. Wadsworth, Ph.D., A.M., F.G.S.

After an enumeration of the divisions of the Azoic and Palæozoic systems of the Upper and Lower Peninsulas of Michigan, the Author describes the mechanically and chemically formed Azoic rocks, and those produced by igneous agency, adding a table which shows his scheme of classification of rocks, and explaining it.

The divisions of the Azoic system are then described in order, beginning with the oldest—the Cascade Formation, which consists of gneissose granites or gneisses, basic eruptives and schists, jaspilites and associated iron ores, and granites.

The rocks of the succeeding Republic formation are given as nearly as possible in the order of their ages, commencing with the oldest:—Conglomerate, breccia and conglomeratic schist, quartzite, dolomite, jaspilite and associated iron ores, argillite and schist, granite and felsite, diabase, diorite and porodite, and porphyrite. The author gives a full account of the character, composition, and mode of occurrence of jaspilite, and discusses the origin of this rock and its associated ores, which he at one time considered eruptive; but new evidence discovered by the State Survey and the United States Survey leads him to believe that he will have to abandon that view entirely.

In the newest Azoic formation, the Holyoke formation, the following rocks are met with:—Conglomerate, breccia and conglomeratic schist, quartzite, dolomite, argillite, greywacke and schist, granite and felsite (?), diabase, diorite, porodite, peridotite, serpentine, and melaphyre or picrite. The conglomerates of the Holyoke formation contain numerous pebbles of the jaspilites of the underlying Republic formation; a description of the Holyoke rocks is given, and special points in connexion with them are discussed.

The Author next treats of the chemical deposits of the Azoic system, gives a provisional scheme of classification of ores, and discusses the origin of ore deposits.

The rocks of the Palæozoic system are next described, and it is maintained that the eastern sandstone of Lower Silurian age underlies the copper-bearing or Keweenawan rocks. The veins and copper deposits are described in detail, and the paper concludes with some miscellaneous analyses and descriptions, as well as a list of minerals found in Michigan.

2. "The Gold-quartz Deposits of Pahang (Malay Peninsula)." By H. M. Becher, Esq., F.G.S.

The gold-quartz deposits of Pahang which traverse an extensive series of slates, sandstones, and dark-coloured limestones, sometimes more or less metamorphosed, and probably of Palæozoic age, occupy the low-lying hill-country on the eastern side of the central granitic mountain-range. The prevailing dip of the strata is eastward.

In some places the auriferous rock penetrates adjacent intrusive syenites, but has not been traced in connexion with the main granitic 'massif' which is generally considered to be the matrix of the cassiterite found in the 'Straits' alluvial Tin-fields.

The gold occurs in lodes and irregular formations, which, however, are not distinguished from one another by any hard-and-fast line; the difference depends on the size, shape, and continuity of the quartz veins, though even the lodes seldom maintain their regularity for more than a few score feet. The quartz often occurs in very narrow veins intersecting one another to form what may be called 'stockworks.' It is probably from these minute veins that the alluvial gold is derived. In the Raub mine numerous rich veinlets occur in a certain zone where the whole slate-rock is charged with iron pyrites, probably auriferous. Many 'stockworks' are intimately associated with dykes or intrusions of a rock which may be called trachyte-porphyry, and these igneous rocks are decomposed where prominently associated with auriferous quartz.

3. "The Pambula Gold-deposits." By F. D. Power, Esq., F.G.S.

The Pambula Gold-field is situated in the parish of Yowaka, County of Auckland, in the South-eastern corner of New South Wales.

The lodes are different from ordinary auriferous deposits, inasmuch as the material filling the ore-channels does not differ greatly in appearance from the 'country' rock, and is but slightly mineralized. The 'country' rock is 'pyrophyllite schist,' associated with 'felspar-porphyry,' sometimes turning into 'quartz-porphyry,' the whole being tilted at a high angle. The bedding and cleavage-planes appear to be coincident. The rock forms lenticles both microscopic and macroscopic. Some of the lodes are accompanied by a quartz 'indicator' which contains little or no gold in itself, the precious metal being found in the shattered 'country' rock of its foot-wall. On the foot-wall side this shattered zone gradually merges into the ordinary 'country' rock. The cause of the parallelism of the auriferous lodes, the mountain-ranges, and the seacoast is discussed, and it is pointed out that the gold does not occur in large grains.

CORRESPONDENCE.

THE ROCKS OF SOUTH DEVON.

Sir,—In Professor Bonney's unfriendly criticism of my paper on the Devonian rocks of South Devon, in the October Number of the Geological Magazine, I am taxed with the commission of three faults among other failings, viz:—

(1) The avoidance of certain apparently possible alternatives which my critic deems of importance.

(2) The not having studied a Devonshire problem in "other fields than South Devon."

(3) The having attempted a research with insufficient materials.

In reply to the first I may state that had I been able to discuss Prof. Bonney's South Devon paper, the points referred to by him would have been satisfactorily disposed of; but I was unable to discuss that paper for the following reason. In October, 1891, Prof. Bonney volunteered to me the statement that he did not mean to enter into any controversy on the subject (of the Devon schists) until his shield was struck by a knight of equal experience. Under the circumstances I had no option but to leave the Professor and his paper alone.

With respect to the second objection, it is evident that the affinities between two sets of Devonshire rocks can only be studied in Devonshire, and not elsewhere. My subject was much more restricted than my critic seems to suppose.

Respecting the charge of insufficiency of materials for research, Prof. Bonney is scarcely in a position to find fault, seeing that he dismissed the whole of the complicated Start headland with the cursory observation—"Two specimens from different parts of the Start headland call for no special remark" (Q.J.G.S. vol. xl. p. 15). Your readers will scarcely be able to realize the significance of this naïve remark.

Southwood, Torquay, A. R. Hunt.
16th November, 1892.

GLACIAL GEOLOGY.

Sir,—I have read with much interest the papers by Mr. Mellard-Reade and Mr. Percy Kendall in your July and November issues. On the one hand we have the submergence theory proved up to the hilt, and on the other the glacier theory sustained with equal show of reason. Does it not strike the combatants that they may both be right and both be wrong? For at one time during the Pleistocene Period the land was certainly deeply submerged in the sea, whilst at another it was with equal certainty enveloped in ice.

There are one or two points in Mr. Kendall's paper to which I should like to refer. Soon after the late Dr. Carvill Lewis came to England, I had the pleasure of showing him the principal sections of Boulder-clay and sand in the Trent Basin, and I think I convinced him that even if there is "a commingling of the Drift" in some deposits in that area, there is also an equally marked absence of commingling in other Drift deposits of the same area. If Mr. Kendall were to try to explain the distribution of the rocks in the Drifts of the Trent Valley on the glacier theory alone he would be in even greater difficulties than he is at present.

Mr. Kendall is not quite accurate in implying that Dr. Carvill-Lewis was the originator of the idea that the valley of the Trent formed a large lake at one time. This was clearly stated in a paper read by me before the Geological Society in 1886. In that paper I make the Middle Pleistocene Epoch open with a "land locked and probably ice-locked" . . . . "Melton-sand sea." Indeed the idea is used to explain the absence of mollusca in the deposits of this epoch. Dr. Carvill Lewis, I think, held that the water level in this sea or lake was above that of the Atlantic; but the facts rather support the view that it was connected with the outside sea, the watershed of Central England being submerged several hundred feet.

It appears to be quite time that the advocates of glacier theories and submergence theories joined hands for the purpose of ascertaining if a more careful study of the "Glacial Succession" will not reconcile their present conflicting views.

R. M. Deeley.

10, Charnwood St., Derby, *Nov. 15th*, 1892.

THE MAMMOTH AND THE GLACIAL DRIFT.

Sir,—In the September Number of the Geological Magazine (p. 405) Sir Henry Howorth writes: "I claim to have shown that, as tested by these islands, the Mammoth beds are in every instance overlain by the Drift, and are never underlain by it;" this claim being limited to cases where it is possible to apply the test of superposition. In my letter of October, I took two of his cases and showed that in both the beds enclosing Mammalian remains were underlain by Glacial Drift, *i.e.*, that the main mass of the local Boulder-clay passed beneath them; thereby disproving the verbal accuracy of his statement.

Again, on p. 400, he discusses the gravels in the valley of the Ouse, near Bedford, a case by the way in which the test of superposition does not apply. In this connection he quotes the discovery of flint-implements "at Thetford on the Ouse," and a few lines lower down he "turns to another site *in the same valley*," being one not far from Bedford (italics are mine). Replying to my obvious comments on this he says he has nothing to correct and nothing to alter in what he wrote, except the spelling of a word, and that the point is "only a test of my knowledge of the English language!" I feel sure your readers will by this time have seen that it was really a test of Sir H. Howorth's knowledge of English geography, and, as I said, of his practical acquaintance with the subject. I did not expect that I should be called upon to point out that the valley of the Little Ouse, between Norfolk and Suffolk, is entirely different and distinct from the valley of the Great Ouse, near Bedford! Not even Sir H. Howorth's approved ingenuity in the use of the English language can make them parts of one and the same valley. There is a Thetford on the Great Ouse, but that is not the place in question.

I do not deny the desirability of his making himself acquainted with the literature of the subject, and a précis of it would be a useful introduction to any detailed memoir on the Pleistocene Deposits; but I do deny that quotations from published papers, however numerous, form a reasonable ground on which to base a claim of having upset the generally accepted views of geologists on any given point.

Neither is it sufficient to deal only with the cases where the test of superposition can be applied; he practically admits this, by referring to the valley of the Great Ouse, but gravels containing Mammoth remains occur in many other valleys which are generally considered to have been eroded out of a wide-spread mantle of Glacial Drift, and this conclusion is not shaken by anything which Sir H. Howorth has written.

Sir Henry may have visited many places and have looked at many sections, but it does not follow that he is qualified to draw sound geological inferences from the phenomena before him. I should be loth to find fault with any one who is seeking to ascertain the truth, but it is the assumption that he has already found the truth by merely sifting the literature of the subject that I venture to protest against.

I feel perfectly sure that if I pointed out a clear case of gravels with Mammoth bones resting on Boulder-clay, Sir H. Howorth would not accept it as final; he would say there might have been another Boulder-clay originally over the gravel, as is supposed by some to be the case at Hoxne.

The question, together with others relating to the glacial deposits, will some day be settled beyond dispute by a man who has acquired an insight into the subject by long experience and by approved practical work in the field, and I am content to await his appearance.

EXETER, *Nov.* 10, 1892. A. J. JUKES-BROWNE.

OBITUARY.

WE regret to announce the death of Mr. Henry John Marten, M.Inst.C.E., F.G.S., etc. Mr. Marten was a well-known hydraulic engineer. He had been engineering adviser to the Board of Agriculture, engineer to the Severn Commissioners and to the Staffordshire and Worcestershire Canal Co. So recently as October 7, he gave evidence before the Royal Commission on Water Supply, on the practicability of constructing storage reservoirs in the Upper Thames Valley. In 1890 he read before the Geological Society a paper "On some Water-worn and Pebble-worn Stones taken from the Apron of the Holt-Fleet Weir on the River Severn" (Quart. Journ. vol. xlvii. p. 63). Mr. Marten died November 3rd, in his *66th year.*

Thomas John Moore, A.L.S., Corr. Memb. Z.S.—We regret to record the death, on October 31st, of Mr. T. J. Moore, for forty years the esteemed curator of the Liverpool Museum. Born in London in 1824, Mr. Moore early evinced an interest in scientific pursuits, and was at the age of nineteen appointed assistant to Mr. John Thompson, curator of the Earl of Derby's Museum at Knowsley. In 1851, when this collection was bequeathed to the Corporation of Liverpool, Mr. Moore became curator, a position he held until the end of last year, when failing health compelled him to tender his resignation. Though more deeply interested in Zoology and Comparative Anatomy than in Geology and Palæontology, Mr. Moore devoted his energies to the perfection of every department of the Museum under his charge, more especially enlisting the services of the sea captains in obtaining acquisitions; and Liverpool at the present time has thus one of the finest and best-arranged of provincial museums. Besides contributing numerous notes on Zoological subjects to scientific journals, and providing material for many specialists who recognized him as a valued collaborator, Mr. Moore took an active part in the spread of scientific teaching among the people, and his popular lectures were always highly appreciated. From 1865 to 1884 he organized the Liverpool Free Public Lectures; and he was an active member of all the bodies in the city devoted to the encouragement of scientific research.

MISCELLANEOUS.

Bristol Museum and Library.—At a well attended meeting of the shareholders, held at the Bristol Museum and Library, Queen's Road, Bristol, on Thursday, November the 3rd, the shareholders adopted a resolution, recommended by the Council, for the transference of the institution to the Corporation of Bristol. The Museum Endowment Fund, £1,475, together with the generous offer of £3,000 made by Sir Charles Wathen, will permit the liabilities to be cleared off. The Buildings, Museum, and Library, are valued at from £30,000 to £40,000, but for some time past the income, derived chiefly from subscriptions, had been inadequate properly to carry on the work, and had gradually declined during the past ten years. By placing the Museum and Library in the hands of the Corporation, their proper maintenance in the future will be assured, and the officials will, it is to be hoped, be adequately paid for their services.

Geological Survey of New South Wales, Sydney.—We understand that Mr. Joseph E. Carne, F.G.S., Curator of the Mining and Geological Museum, Sydney, N. S. Wales, who so ably assisted the late Mr. C. S. Wilkinson, F.G.S., during the Mining and Metallurgical Exhibition at the Crystal Palace, Sydenham, in 1890, has been appointed by the Minister of Mines to the post of geological surveyor, with a salary of £400 per annum. Mr. Carne entered the service of the N. S. Wales Government in 1879, and has proved himself to be in every way a most able and efficient officer, and has won the esteem and regard of all with whom he has come in contact.

INDEX.

ABSENCE of Glaciation in parts of Europe and Asia, 54.
Acanthodes semistriatus, sp. nov., A. S. Woodw., 3.
Address by Prof. Lapworth, 415, 470.
Affinities between Devonian Rocks and Metamorphic Schists, 241, 341.
Agelacrinites, from the Carboniferous Limestone of Cumberland, 88.
Age of the Himalayas, 161.
Alaska, the Muir Glacier, 428.
Alps of Savoy, 567.
Ammonites, Comments on Inferior Oolite, 76.
Ammonites Jurensis, in the Northampton Sands, 258.
Annual General Meeting of the Geological Society, 182.
——— Report, Geol. Surv. Western Australia, 132.
Annals of British Geology, 45.
Aphidæ, and Tettigidæ, Notes on Fossil, 228.
Archæopneustes abruptus, from Barbados, 89.
Archæan Limestones on the Flanks of the Malverns, 239.
Arctic Plants found Fossil near Edinburgh, 467.
Ash-Slates and other Rocks in the Lake District, 154, 218.
Astronomical Theory of Glaciation, 260.
Augitite, On Irish, 348.
Austin, Stephen, Obituary of, 335.
Australian Fossil Echinoidea, 433.
Azoic Rocks of Brittany, Presence of Fossils in the, 566.

BAGSHOT Beds of Bagshot Heath, 88, 332.
Ball, R., The Cause of the Ice Age, 231.
Barrois, C., on the Fauna of the Grès Armoricain, 126; Presence of Fossils in the Azoic Rocks of Brittany, 566.
Barrow, G., Certain Gneisses and their Relation to Pegmatites, 64.
Basalts and Andesites of Devonshire, 383.
Becher. H. M., The Gold-Quartz deposits, of Pahang, 572.
Bell, D., The Chapelhall "Shell-bed," 521.
Black Limestones of Malta, 361.
Blake, J. F., Cambrian Rocks in Caernarvonshire, 41; Replies to various Criticisms, 168.
Blanford, W. T., Age of the Himalayas, 161.
Bonney, T. G., Granite Cutting Cretaceous Rocks, 43; Crystalline Schists of the Lepontine Alps, 90; on the so-called Gneiss of Carboniferous Age at Guttannen, 275; the Rocks of South Devon, 479.
Borings for Salt and Coal, 383.
Borneo: Its Geology and Mineral Resources, 568.
Boulder-clay Beneath the Ice, 305.
Bridport, Liassic Sections near, 437.
Britain, *Trematonotus* found in, 337.
British Association, 413, 463.
——— Earthquakes, 299.
——— Pliocene Vertebrata, 79.
Bristol Museum, 576.
Brodie, P. B., a Sand Pit at Hill Morton, 321.
Brown, A. P., Development of the Shell of *Baculites compressus*, 372.
Brown, R. G. M., Precipitation and Deposit of Sea-borne Sediments, 238.
Bryozoa, North Italian, 136.
Buckman, S. S., Reply to Prof. Blake's Comments on Inferior Oolite Ammonites, 76; Reported Occurrence of *Ammonites jurensis* in the Northampton Sands, 258; Morphology of *Stephanoceras zigzag*, 331.
Buckton, G. B., Notes on Fossil *Aphidæ* and *Tettigidæ*, 228.
Builth, Igneous Rocks of the Neighbourhood of, 565.
Bulletin of the United States Geological Survey, 179.
Bulman, G. W., Drift Coal in Sandstone, 150; the Revised Astronomical Theory of Glaciation, 260; Was the Boulder-clay formed under the Ice? 305; "Underclays," 351.

CALLAWAY, C., Cambrian Quartzites in Shropshire, 46; Schist-making in the Malvern Hills, 545.
Cambrian in Caernarvonshire, Rocks Mapped as, 41.

Cameron, A. C. G., on the Continuity of the Kellaway Beds, near Bedford, 66 : Note on a Green Sand in the Lower Greensand, 469.
Canada, Devonian Fish-fauna of, 481.
——— Annual Report of the Geological Survey of, 175.
——— Royal Society of, 374.
Carboniferous *Murchisonia*, 382.
Card, G. W., on the Flexibility of Rocks, 117, 525.
Carson, A., Rise and Fall of Lake Tanganyika, 274.
Carus-Wilson, C., on Flexible Sandstone, 429.
Cassidulus florescens, sp. nov., J. W. Gregory, 435.
Cayeux, L., *Cyprina planata*, and the Diatom Beds of the North of France, 31 : on *Radiolaria* in the Jurassic and Eocene of the North of France, 172.
Chonetes Pratti, from Western Australia, 468, 542.
Chapman, T., New Forms of Hyaline Foraminifera from the Gault, 52 ; Microzoa from the Phosphatic Chalk of Taplow, 383.
Clarke, J. M., Discovery of *Clymenia* in North America, 173.
Claypole, E. W., A Bed of Peat in the London Clay ? 524.
"Cleat" in Coal-seams, 523.
Coal, Drift in Sandstone, 150.
—— South of the Mendips, 38.
Coccosteus canadensis, sp. nov., A. S. Woodw., 483.
Cole, G. A. C., Lake-District Rocks, 43 ; on the Lithophyses in the Obsidian of the Roche Rosse, Lipari, 275.
"Colonie Haidinger" *Discinocaris*, New Species from the, 148.
Comments on Inferior Oolite Ammonites, 76.
Composition and Structure of the Hirnant Limestone, 114.
Conchological Nomenclature, 90.
Concretions, 384.
Coniston Limestone, 97, 295, 443, 526.
Cone-in-Cone Structure, 138, 240, 278, 334, 432, 480, 505.
Cooke, J. H., on the Black Limestones of Malta, 361.
Cope, E. D., on the Characters of some Palæozoic Fishes, 233.
Crawford, J., Geological Survey of Nicaragua, 382.
Cretaceous Saw-Fish, Description of, [illegible]
Criticisms, Replies to Various, by Rev. J. F. Blake, 168.
[illegible] Rocks of Sark, 134.

Crystalline schists, 5.
——— ——— of the Lepontine Alps, [illegible]
Crystallines at Malvern, 452.

DACRYTHERIUM ovinum, from the Isle of Wight, 39.
Dakyns and Teall, on the Plutonic Rocks of Garabal Hill and Meall Breac, 135.
Dana, E. S., Descriptive Mineralogy, 367.
Davison, C., Nature and Origin of Earthquake Sounds, 208 ; on British Earthquakes, 299.
Deeley, R. M., Glacial Geology, 573.
Delphinognathus conocephalus, from the Karoo Beds, 329.
Development of the Shell of *Baculites compressus*, 372.
Devon and Cornish Granites, 467.
Devon, Rocks of South, 573.
Devonian Volcanics, 290.
Devonshire, Permian in, 247.
Diatom and *Cyprina planata* Beds in the North of France and Belgium, 31.
Discinocaris, in the Graptolite Beds of Bohemia, 148.
——— *Dusliana*, sp. nov., Novák, 148.
Dicynodont and other Reptiles from the Elgin Sandstone, 515.
Diplacanthus horridus, sp. nov., A. S. Woodw., 482.
Diplodus problematicus, sp. nov., A. S. Woodw., 2.
Dioritic Picrite of the White Hause and Great Cockup, 380.
Divining Rod Again, 528.
Dissipation of Energy as a Geological Factor, 279.
Donald, Miss J., Carboniferous *Murchisonia*, 382.
Dover, W. K., Obituary of, 47.
Drew, F., Obituary of, 142.
Drift Beds of the North- and Mid-Wales Coasts, 190.
—— Coal in Sandstone, 150.
Durham, the Flexible Limestone of, 117.

EARTHQUAKE of Japan, the Great, 322.
——— Phenomena in Japan, 465.
——— Sounds, 280.
——— ——— Nature and Origin of, 208.
Earthquakes, on British, 299.
Echinoidea, Australian Fossil, 433.
Elevation of Submerged Lands, 405.

Elgin, Dicynodont and other Reptile Remains from, 515.
Emerald Mines, an Account of, 274.
Endothiodon bathystoma, Further Evidence of, 330.
England, Lamprophyres of the North of, 199.
Etheridge, R., jun., Carboniferous Invertebrata of New South Wales, 36.
Eunotosaurus africanus, a New Reptile, 380.

FAULT without a Throw, 191.
Faulting in Drift, 490.
Fauna of the "Grès Armoricain" in Brittany, 126.
——— —— *Olenellus* Zone in North Wales, 21.
Fish-Fauna of Campbellton, 1.
————— of Canada, 481.
Flexible Sandstone, 355, 429.
Flexibility of Rocks, 117, 525.
Flower, Sir W. H., K.C.B., 432.
Floyer, E. A., Geology of North Etbai, 274.
Foraminifera from the Gault, 52.
Forfar, New Species of *Onychodus* from the Old Red Sandstone of, 51.
Fossil Dragon Flies, 170.
—— Insects of North America, 128.
—— of the Upper Trias, St. Cassian, 145.
—— Radiolaria, 172.
Fossils, Improved Method of taking Impressions of, 206.
Formation of Landscape Marble, 110.
Fraas, E., The Paddles and Fins in *Ichthyosaurus*, 516.
Fulcher, L. W., Composition and Structure of the Hirnant Limestone, 114.
Fuller's Earth Works at Woburn, 66, 469.
Furcheim, F., the South Italian Volcanoes, 181.

GARWOOD, E. J., Concretions in Magnesian Limestone, 44; Cone-in-Cone Structure, 334.
Geology of Barbados, 88.
——— Notes on Russian, 385, 549.
——— of the Lizard District, 364.
——— —— Wengen and St. Cassian Strata, 381.
Geological Map of Scotland, 528.
———— Notice of the Boulonnais, 370.
———— Society of London, 39, 81, 134, 182, 237, 274, 329, 377, 571.
———— Survey in Nicaragua, 382.
Geological Survey of Canada, 175.
———— ——— of New South Wales, 576.
———— ——— of Western Australia, 132.
Gemmellaro, G. G., Crustacea of the Fusulina Limestone of Sicily, 78.
Gibson, Walcot, Geology of the Gold-bearing Rocks of the Transvaal, 238.
Glacial Drift, the Mammoth and the, 250, 396, 502.
——— Geology, 310, 491, 573.
——— Gravels, High Level, at Gloppa, 42.
Glaciation, Absence of, in parts of Europe and Asia, 54.
———— Revised Astronomical Theory of, 260.
Glen Roy, Supplementary Remarks on, 39.
Gneiss of Carboniferous Age at Guttannen, Berne, 275.
Gneisses and their Relation to Pegmatites, 64.
Gold-deposits of Pambula, 572.
Goodchild, J. G., Improved Method of taking Impressions of Fossils, 206; on the Coniston Limestone Series, 295, 526; Granite Junction in Mull, 447; St. Bees Sandstone and its Associated Rocks, 564.
Grampian Series, 463.
Granite, 561.
Granite Cutting Cretaceous Rocks, 43.
Gravels South of the Thames, between Guildford and Newbury, 87.
Greensand, 469.
Gregory, J. W., *Archæopneustes abruptus*, a new Genus and Species of Echinoid from Barbados, 89; Australian Fossil Echinoidea, 433.
Gresley, W. S., Cone-in-Cone Structure, 432; Theory for "Cleat" in Coal-seams, 523.
Griesbach, C. L., Geology of the Central Himalayas, 268.
Guide to Building Materials in the Vienna Museum, 133.
———— the Geological Galleries at Edinburgh, 476.
Guppy, R. J. L., Tertiary Microzoic Formation of Trinidad, 331.

HARKER, A., The Lamprophyres of the North of England, 199; Cone-in-Cone Structure, 240; Appendix to Mr. Hunt's paper, 346; Porphyritic Quartz in Basic Igneous Rocks, 485.
Hatch, F. H., A new British Phonolite, 149.

Hicks, H., on the Fauna of the Olenellus Zone in Wales, 21; on the Grampian Series, 463.
Highland Gneisses, on Certain, 64.
Hill, E., Rapid Elevation of Submerged Lands, 405.
——— and Bonney, T. G., on the Crystalline Rocks of Sark, 134.
Hill-Morton, a Sandpit at, 321.
Himalayas, Age of the, 161.
——— Geology of the Central, 268.
Hirnant Limestone, Composition and Structure of, 114.
Hitchin, Iguanodont Tooth from the Lower Chalk near, 49.
Hobson, B., an Irish Augite, 348; on the Basalts and Andesites of Devonshire, 383; on the Phosphatic Chalk at Taplow, 524.
Holm, G., on the Aperture in the genus *Lituites*, 128; Concerning the Dimensions of *Olenellus*, 139.
Holmes, T. V., the New Railway from Thurrock to Romford, 190.
Howorth, H. H., Absence of Glaciation in parts of Europe and Asia, 54; Did the Mammoth live Before the Deposition of the Glacial Drift? 250, 396; Recent Elevation of the Himalayas, 276; The Mammoth and the Glacial Drift, a Reply to Mr. Jukes-Browne, 502.
Hull, E., Comparison of Red Rocks of South Coast, Midland and West of England, 40.
Hume, W. F., Notes on Russian Geology, 385, 549.
Hunt, A. R., Affinities between the Devonian Rocks of South Devon and the Metamorphic Schists, 241, 290, 341; the Metamorphic Rocks and Devonian Volcanoes, 289; Rocks of South Devon, 573.
Hutchinson, H. N., The Story of the Hills, 235.
Hutchings, W. M., Ash-Slates and other Rocks in the Lake District, 154, 218.
Hutton, F. W., Classification of the Moas of New Zealand 125.
Hyaline Foraminifera from the Gault, 62.

ICE AGE, Cause of an, 231.
Ice, was the Boulder-Clay formed Beneath the, 305.
Ichthyosaurus, The Paddles and Fins of, 516.
Iguanodont Tooth, from the Lower Chalk, Hitchin, 49.
Interglacial Period in Central Russia, 328.
Irish Augitite, 348.
Iron-ore Deposits in Norway and Sweden, 82.
Irving, A., Red Rocks of the Devon Coast Section, 41; Archæan Limestones on the Flank of the Malverns, 239; Dissipation of Energy as a Geological Factor, 279; Bagshot Beds of Bagshot Heath, 332; Permian in Devonshire, 333; Malvern Crystallines, 452.

JAMIESON, T. F., Supplementary Remarks on Glen Roy, 39.
Jervis, Cav. G., The Geology of Pantellaria, 171.
Johnson and Richmond, on the Geology of the Nile Valley, 332.
Johnston-Lavis, H. J., Earthquake Sounds, 280; Report on Volcanic Phenomena, 507; Obsidian of the Rocche Rossi Lipari, 488.
Jones, T. R., on the Fossil Phyllopoda of the Palæozoic Rocks, 513.
Jukes-Browne, A. J., Reade's Theory of Mountain Building, 24, 139; Needless Alteration of Zoological Names, 47; the Mammoth and the Glacial Drift, 477, 574; Handbook of Physical Geology, 570.
——— ——— and Harrison, the Geology of Barbados, 88.
Junction in the Ross of Mull, 447.
Jupiter Serapis, The Temple of, 282.

KARRER, Felix, Collection of Building Materials in Vienna Museum, 133.
Kellaway Beds, Continuity of, 66.
Kendall, P. F., Glacial Geology, 491.
Killan, M. W., on the Geological Structure of the Alps of Savoy, 567.
Kirkby, W. F., a Synonymic Catalogue of *Neuroptera Odonata*, 170.
Koenen, A. von, the North German Oligocene and their Molluscan Fauna, 325.
Krischtafowitsch, N., an Interglacial Period in Central Russia, 328.

LAGANUM decagonale, var. *rictum*, var. nov., J. W. Gregory, 433.
Lake-District, Ash-Slates of the, 154, 218.
——— Rocks, 43.
——— ——— Wenlock and Ludlow, Strata of the, 534.
Lamprophyres of the North of England, 199.

Landscape Marble, Formation of, 110.
Lapworth, C., Geology of the Wengen and St. Cassian Strata, 381; Address to Section C. Geology, 416, 470.
Lepontine Alps, Mesozoic Rocks in the, 6.
Liassic Sections near Bridport, 437.
Limestone Series, Coniston, 97, 295, 443, 526.
Lithophyses in the Obsidian of the Rocche Rossi, 275, 488.
Lituites, on the Aperture in the Genus, 128.
Lizard District, Observations on the Geology of the, 364.
——— Relations of the Rocks of the, 565.
Lleyn, the so-called Serpentines of the, 408.
Lomas, J., on a Fault without a Throw, 191; Shapes of Sand Grains, 527.
Lower Lias Insect from Barrow-on-Soar, 193.
Lydekker, R., on *Dacrytherium ovinum*, from the Isle of Wight, 39; Annals of British Geology, 45; on Part of Pelvis of *Polacanthus*, 87; on the Occurrence of the so-called *Viverra Hastingsiæ*, in the French Phosphorites, 237; Notes on two Dinosaurian Foot-bones from the Wealden, 237.

MACMAHON, C. A., Manufacture of Serpentine in Nature's Laboratory, 71; Reply to Prof. Blake, 240.
Maltese Islands, Black Limestone in, 361.
Malvern Crystallines, 452.
——— Hills, Schist-making in the, 545.
Mammoth and the Glacial Drift, 250, 396, 477, 502, 574.
——— Remains in Endsleigh Street, 330.
Marr, J. E., the Coniston Limestone Series, 97, 443. On the Wenlock and Ludlow strata of the Lake District, 534.
Marten, Henry John, Obituary of, 575.
Medals and Funds of the Geological Society, 81.
Mesosauria of South of Africa, 379.
Metamorphic Green Rocks, 290.
——— Schists and Devonian Rocks, 241, 290, 341.
Method of Taking Impressions of Fossils, 206.
Microscopic Structure of Devonian Limestone, 237.
Microzoa from the Phosphatic Chalk of Taplow, 383.
Microzoic Formations of Trinidad, 331.
Michigan, A Sketch of the Geology of, 571.
Milne, J., on Earthquake Phenomena in Japan, 465.
Milne, J., and Burton, W. K., the Great Earthquake in Japan, 322.
Mineralogy, Dana's System of, 367.
Moas of New Zealand, Classification of the, 125.
Mollusca of the North German Oligocene Beds, 325.
Monckton, H. W., Gravels South of the Thames from Guildford to Newbury, 87; the Bagshot Beds of Bagshot Heath, 88.
Moore, T. J., Obituary of, 576.
Morton, G. H., Subterranean Erosion of Glacial Drift, 430.
Morphology of *Stephanoceras zigzag*, 331.
Mountain-Building, Reade's Theory of, 24, 91, 139.
Mountains and How they were Made, 235.
Mull, Granite Junction in the Ross of Mull, 447.
Museum Notes, Woodwardian, 548.

NATURE'S Manufacture of Serpentine, 71.
Neuropterous Insects from Barrow-on-Soar, 193.
Newton, E. T., Iguanodont Tooth from the Lower Chalk, near Hitchin, 49; a New Species of *Onychodus*, 51; the Vertebrata of the Pliocene Deposits of Britain, 79; *Dicynodont* and other Reptile Remains from the Elgin Sandstone, 515.
——— R. B., Conchological Nomenclature, 90; on the American Genus *Trematonotus* and its Identification in Britain, 337, 525; *Chonetes Pratti*, in the Carboniferous Rocks of Western Australia, 468, 542.
New Brunswick, Lower Devonian Fish-Fauna of, 1.
Nicholson, A. C., High-Level Glacial Gravels, near Oswestry, 42.
Nile Valley, the Geology of, 332.
Noetling, F., Field Notes from the Shan Hills, 521.
North America, Discovery of *Clymenia* in, 173.
Northampton Sands, Occurrence of *Ammonites Jurensis* in the, 258.
Norton, Henry, Obituary of, 192.
Novák, Ottamar, New Form of *Discinocaris* in the Graptolite Beds, Bohemia, 148.

OBITUARY of W. K. Dover, 47; Sir A. C. Ramsay, 48; Dr. F. von Roemer, 48, 92; F. Drew, 142; H. Norton, 192; W. Reed, 283; S. Austin, 335; H. J. Marten, 575; T. J. Moore, 576.

Ogilvie, M. M., Sequence of Fossils of the Upper Trias of St. Cassian, Tyrol, 145.
Olenellus, Concerning the Dimensions of, 139.
——— Zone, Fauna of the Lower Cambrian or, 32.
——— —— in the North West Highlands, 137.
——— —— in North Wales, Fauna of the, 21.
Onychodus from the Old Red Sandstone of Forfar, 51.
——— *scoticus*, sp. nov., E. T. Newton, 51.
Oolites of Northamptonshire, 228.
Organization of the Receptaculitidæ, 518.
Origin of Earthquake Sounds, 208.
Orthoceratidæ of the Trenton Limestone, 373.
Osten Sacken, C. R., Alteration of Geological Names, 47.

PAHANG, The Gold-quartz Deposit of, 572.
Palæotermes Ellisii, H. Woodward, Genus and Species New, 198.
Palæozoic Fishes, on the Character of some, 232.
——— Fossils from Kotelny Island, near Siberia, 31.
——— Invertebrate Fossils of New South Wales, 36.
Pantellaria, the Geology and Mineral Springs of, 171.
Pavlow and Lamplugh, the Speeton Beds and their Russian Equivalents, 422.
Peach and Horne, the *Olenellus* Zone in the North-West Highlands, 137.
Peal, S. E., Selenology, 500.
Peat and Forest-bed, Cause of Submergence, 42.
—— in the London Clay, 524.
Permian in Devonshire, 247, 333.
Phonolite, a New British, 149.
Phosphatic Chalk at Taplow, 524.
Phyllopoda, Fossil of the Palæozoic Rocks, 513.
Physical Geology, 570.
Pittman, E. F., Flexible Sandstone, 335.
Plant, Major John, retirement of, 286.
Pleistocene Deposits of the Sussex Coast, 189.
Plutonic Rocks of Garabal Hill and Meall Breac, 135.
Polacanthus, on Part of the Pelvis of, 87.
——— *Foxi*, on the Os pubis of, 40.
Polymorphina Orbignii, var. nov. *Cervicornis*, F. Chapman, 54.
Porphyritic quartz in Basic Igneous Rocks, 485.
Posewitz, T., The Geology of Borneo, 568.
Possible Results of Rapid Elevation of Submerged Lands, 405.
Postlethwaite, J., Dioritic Picrite of White Hause, 380.
Powell, J. W., Report of the United States Geological Survey, 177.
Power, F. D., The Pambula Gold-deposits, 572.
Preliminary Study of Underclays, 351.
Prestwich, J., the Raised Beaches of the South of England, 136, 188.
Precipitation and Deposition of Sea-borne Sediment, 238.
Proceedings of the Yorkshire Geological Society, 271.
Process of Schist-making in the Malvern Hills, 545.
Protodus Jexi, A. S. Woodward, Genus and Species, New, 1.

RAISED Beaches of the South of England, 136, 188.
Ramsay, Sir A. C., Obituary of, 48.
Raisin, C. A., So-called Serpentines of the Lleyn, 408.
Rauff, H., Organization and Systematic Position of the Receptaculitidæ, 518.
Reade, T. M., Reade's Theory of Mountain Building, 91, 191; Drift Beds of the North and Mid-Wales Coast, 190; Glacial Geology Old and New, 310; Shapes of Sand Grains, 478; Faulting in Drift, 490.
Reade's Theory of Mountain Building, 24, 91, 191.
Recent Elevation of the Himalayas, 276.
Red-Rocks of Devon Coast Section, 41.
——— of South Devon Coast and Midland and Western Counties, 40.
Reed, F. R. C., Woodwardian Museum Notes, 548.
Reed, H. F., The Muir Glacier, 428.
Reed, William, Obituary of, 283.
Reid, Clement, the Pleistocene Deposits of the Sussex Coast, 189; Fossil Arctic Plants found near Edinburgh, 467.
Replies, the Rev. J. F. Blake's, to Various Criticisms, 168.
Reply to Mr. Jukes-Browne, by Sir H. H. Howorth, 502.
—— — Prof. Blake, 240.
Ricketts, C., Concretions in Magnesian Limestone, 46.
Rigaux, E., on the Boulonnais, 370.
Rise and Fall of Lake Tanganyika, 274.
Roemer, Dr. Ferdinand von, Obituary of, 48, 92.

Rocks of South Devon, 479, 573.
Royal Society of Canada, 374.
Russian Geology, 385, 549.
Rüst, Dr., Fossil Radiolaria from the Triassic and Palæozoic Strata, 326.

SACH, A. J., Simple Cone-in-Cone Structure found in New South Wales, 505.
Sand-pits at Hill Morton, near Rugby, 321.
Saurischia of Europe and Africa, 377.
Sclerorhynchus atavus, A. S. Woodward, 529.
Scudder, S. H., Fossil Insects of North America, 128.
Sections between Upminster and Romford, 190.
Seeley, H. G., Prof., on the Os pubis of *Polocanthus Foxi*, 40; on *Delphinognathus conocephalus* from Cape Colony, 329; further evidence of *Endothiodon bathystoma*, from Cape Colony, 330; Saurischia of Europe and Africa, 377; Mesosauria of South Africa, 379; New Reptile from the Velte Vreden, 380.
Selenology, 500.
Serpentine, Nature's Manufacture of, 71.
Serpentines of the Lleyn, so-called, 408.
Sban Hills, Upper Burma, Field Notes from, 521.
Shapes of Sand Grains, 429, 478.
Sharman, G., and Newton E. T., on a New Form of *Agelacrinites* from Cumberland. 88.
Sheppey, *Xanthidia* in the London Clay of, 28.
Shell-bed near Airdrie, 521.
Shone, W., Subterranean Denudation of the Glacial Drift, 42.
Shropshire. Cambrian Quartzites in, 46.
Sicily, Contributions to the Palæontology of, 78.
Smith, William, a Monument to, 94, 144.
Somervail, A., Observations on the Geology of the Lizard District, 364. Relations of the Rocks of the Lizard District, 565.
Speeton Beds and their Russian Equivalents, 422.
Springer, F., the late P. H. Carpenter, 44.
Stapff. Dr. F. M., on the Crystalline Schists of the Lepontine Alps, 6.
St. Bees, Sandstone and its Associated Rocks, 564.
St. Cassian, Fossils from the Upper Triassic Strata of, 145.
Strultiers, T. R., Granite, 561.
Subterranean Erosions, 430.

TATE, T., Boring for Salt and Coal in the Tees District, 383.
Terebratulina substriata, found in Yorkshire, 364.
Tertiary Microzoic Formation of Trinidad, 331.
Titles of Papers read in Section (C) Geology, 413.
Thecidea, On Yorkshire, 548.
Thompson, Beeby, Oolitic Rocks at Stowe-nine-Churches, 228.
Thomson, J. E. H., the Temple of Jupiter Serapis, 282.
Toll, Baron E. von, Palæozoic Fossils from Kotelny Island, 31.
Transvaal, Gold-bearing Rocks of the Southern, 238.
Trematonotus Britannicus, sp. nov., R. B. Newton, 339.
——— found in Britain, 337.
——— on the Genus, 525.
Triassic and Palæozoic Radiolaria, 326.
Type Fossils in the Woodwardian Museum, 235.

UNDERCLAYS, a Preliminary Study, 351.
United States, Geological Survey, 177, 179.
Ussher, W. A. E., Palæozoic Strata in the Southern Counties, 38; Permian in Devonshire, 247; Devon and Cornish Granites, 467.

VITRIWEBBINA Sollasi, F. Chapman, Genus and Species New, 53.
Vogt, J. H. L., on the Formation of Iron Ores, 82.
Volcanic Phenomena of Vesuvius and its Neighbourhood, 507.
——— Rocks of Colombia, 426.
Volcanoes, the South Italian, 181.

WADSWORTH, M. E., Geology of Michigan, 571.
Walcott, C. D., Fauna of the Olenellus Zone, 32.
Walker, J. F., Discovery of *Terebratulina substriata* in Yorkshire, 364; on Liassic Sections near Bridport, 437; On Yorkshire Thecidea, 548.
Waters, A.W., on North Italian Bryozoa, 136.
Wenlock and Ludlow Strata of the Lake District, 534.
Western Australia, *Chonetes Pratti*, from 468, 542.

Wethered, E., Microscopic Structure in the Devonian Limestones of South Devon, 237.
Wetherell, E. W., on *Xanthidia* in the London Clay of Sheppey, 28.
Whiteaves, J. F., the Orthoceratidæ of the Trenton Limestone, 373.
Woods, Henry, Catalogue of the Type Fossils in the Woodwardian Museum, 235; Igneous Rocks of the neighbourhood of Builth, 565.
Woodward, A. S., Lower Devonian Fish-Fauna of Campbellton, 1; Devonian Fish-Fauna, of Canada, 481; Description of the Cretaceous Saw-Fish, 529.
——— Henry, a Neuropterous Insect from the Lower Lias of Barrow-on-Soar, 193.
——— H. B., Remarks on the Formation of the Landscape Marble, 110.
Woodward, H. P., Annual Report for 1890, Geological Survey of Western Australia, 132.
Woodwardian Museum Notes, 548.

XANTHIDIA in the London Clay of Sheppey, 28.

YORK Museum, 384.
Yorkshire Geological and Polytechnic Society, 271.
——— *Terebratulina substriata*, Discovered in, 364.
——— Thecidea, On, 548.
Young, John, Cone-in-Cone Structure, 138, 278, 480.

ZOOLOGICAL Names, Needless Alteration of, 47.

PRINTED BY STEPHEN AUSTIN AND SONS, HERTFORD.

✓

Stanford University
Stanford, Califo

Return this book on or befor

[redacted]-CIRCUL